N72-20800

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Technical Memorandum 33-523

Volume I

Tracking and Data System Support for the Mariner Mars 1971 Mission

Prelaunch Phase Through First Trajectory Correction Maneuver

R. P. Laeser

G. P. Textor

L. B. Kelly

M. Kelly

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

March 15, 1972

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Technical Memorandum 33-523

Volume I

Tracking and Data System Support for the Mariner Mars 1971 Mission

Prelaunch Phase Through First Trajectory Correction Maneuver

R. P. Laeser

G. P. Textor

L. B. Kelly

M. Kelly

JET PROPULSION LABORATORY

CALIFORNIA INSTITUTE OF TECHNOLOGY

PASADENA, CALIFORNIA

March 15, 1972

PREFACE

The work described in this report was performed by the Tracking and Data Acquisition organizations of the Jet Propulsion Laboratory, Air Force Eastern Test Range, Manned Space Flight Network, and the NASA Communications Network of Goddard Space Flight Center. This volume covers the Tracking and Data System support for the Mariner Mars 1971 Mission from the planning phase through the first trajectory correction maneuver; Volume II will contain a description of the TDS flight support from the first trajectory correction maneuver through orbit insertion, including TDS support of pre-orbital training and testing; Volume III will cover TDS flight support of the orbital operations for Mariner Mars 1971; and Volume IV will include TDS flight support of the extended mission.

In this Technical Memorandum, values in customary units are included in parentheses after values in International System (SI) units if the customary units were used in the measurements or calculations.

ACKNOWLEDGMENTS

The authors acknowledge the assistance of the technical staffs of the several agencies providing tracking support: The Air Force Eastern Test Range of the Department of the Defense, the Manned Space Flight Network of the Goddard Space Flight Center, and the Deep Space Network of the Jet Propulsion Laboratory. Information relative to the launch vehicle was obtained from reports of the Lewis Research Center; information relative to the mission and the spacecraft was obtained from the Mariner Mars 1971 Project reports. Information regarding the Deep Space Network is based upon material generated by the DSN Interface Team for the Mariner Mars 1971 Project and the DSN Operations staff. The authors wish to especially acknowledge the assistance of the following DSN personnel:

R. M. Grace	Near-Earth Phase Support
A. I. Bryan	Spacecraft Compatibility
E. L. Dunbar	Simulation

Deep Space Network/Mariner Mars 1971 Interface Team

D. W. H. Johnston	Deep Space Instrumentation Facility
W. G. Meeks	Deep Space Instrumentation Facility
J. W. Capps	Ground Communications Facility
M. D. Weidner	Ground Communications Facility
L. E. Jennings	Space Flight Operations Facility

DSN Operations Staff, Network Analysis Team Chiefs

J. E. Allen	Monitor
W. C. Harris	Telemetry
R. B. Miller	Tracking
W. G. Stinnett	Command

The authors are indebted to G. M. Truszynski, A. C. Belcher, and M. E. Binkley of the Office of Tracking and Data Acquisition, National Aeronautics and Space Administration, for their support. The authors also wish to thank J. A. Bain of the JPL Tracking and Data Acquisition Documentation Group and Mrs. M. F. Buehler of the JPL Publications Section for their assistance.

CONTENTS

CONTENTS (contd)

CONTENTS (contd)

TABLES

CONTENTS (contd)

TABLES
(contd)

TABLES (contd)

FIGURES

FIGURES (contd)

FIGURES (contd)

ABSTRACT

The Tracking and Data System support for the Mariner Mars 1971 Project was planned and implemented in close cooperation with the Mission Operations and Spacecraft Systems of the Project. The Project requirements for tracking, telemetry, command, mission control, and compatibility testing during this period were reviewed for matching to Deep Space Network (DSN) capabilities. The DSN capabilities to support the Project were set forth in an Operation Plan describing the design of the DSN systems formulated for the support of this particular Project. Each of the systems is described.

A new feature of the Tracking and Data System for the Mariner Mars 1971 Project was the new DSN command system, which provided the capability to enter commands in a computer at the deep space stations for transmission to the spacecraft, all automatically. Another new feature was the High-Rate Telemetry System operating at 16, 200 bits/s. This high-rate system, which was only experimental for the previous (Mariner Mars 1969) mission, will permit return to DSS 14 of full-resolution television pictures from the spacecraft tape recorder, plus the other science experiment data, during the two playback periods of each Goldstone pass planned for each corresponding orbit.

Other new features included 4800-bits/s modem high-speed data lines from all deep space stations to the Jet Propulsion Laboratory Space Flight Operations Facility (SFOF) and the Goddard Space Flight Center, as well as 50,000-bits/s wideband data lines from DSS 14 to the SFOF, thus providing the capability for data flow of two 16, 200-bits/s high-rate telemetry data streams in real time.

The TDS performed prelaunch training and testing and provided support for the Mariner Mars 1971/Mission Operations System training and testing. The facilities of the Air Force Eastern Test Range, Deep Space Station 71 of the DSN, and stations of the Manned Space Flight Network provided flight support coverage at launch and during the near-Earth phase. Deep Space Stations 12, 14, 41, and 51 of the DSN provided the deep space phase support from launch date, May 30, 1971, through the first trajectory correction maneuver on June 4, 1971, the end of the period covered in this Volume I report.

Analysis of the support performance shows that all tracking and telemetry data received on Earth were acquired, processed, and delivered to the Project. All commands were transmitted successfully.

I. INTRODUCTION

A. Purpose

This document, Volume I, covers the Tracking and Data System (TDS) activities in support of the Mariner Mars 1971 Project (MM '71) from the system design phase through prelaunch, launch, and first trajectory correction maneuver. With the completion of subsequent Volumes II through IV, this report constitutes the complete history of TDS activities supporting MM '71. The Project provided two spacecraft, Mariners 8 and 9, one of which (Mariner 9) carried out a successful mission to Mars.

B. Scope

Volume I contains a description of TDS support of prelaunch testing for both near-Earth and deep space phases (Section IV) and TDS flight support from launch operations through first trajectory correction maneuver (Section V). Requirements placed on the TDS (Section II), TDS plan and configuration (Section III), and performance evaluation (Section VI) are also included.

C. TDS Agencies

The TDS provided support to MM '71 for all tracking and data acquisition (TDA) activities required to meet mission objectives (paragraph E below). The TDS is composed of facilities and resources of four major support agencies:

(1) Air Force Eastern Test Range. The U.S. Air Force, through the Air Force Systems Command and the National Range Division, manages the Air Force Eastern Test Range (AFETR) for the Department of Defense (DOD). As lead range for MM '71, the AFETR arranged the required support from DOD resources. The AFETR provided prelaunch and launch support for Mariners 8 and 9, and near-Earth TDS support for Mariner 9. Partial near-Earth TDS support for Mariner 8 ended abruptly with the failure of the Centaur guidance and loss of the spacecraft a few minutes after launch.

(2) Manned Space Flight Network. The Manned Space Flight Network (MSFN), operated for the National Aeronautics and Space Administration (NASA) by the Goddard Space Flight Center (GSFC), provided near-Earth tracking and data acquisition support for Mariners 8 and 9.

(3) NASA Communications System. The NASA Communications System (NASCOM), operated for NASA by the GSFC, provided ground communications circuits required for support of Mariners 8 and 9.

(4) Deep Space Network. The Deep Space Network (DSN), operated for NASA by the Jet Propulsion Laboratory (JPL), provided mission support in the areas of deep-space tracking, metric and telemetry data acquisition, and spacecraft command transmission. Mission operations support was provided by the DSN through three component facilities: (1) Deep Space Instrumentation Facility (DSIF), (2) Ground Communications Facility (GCF), and (3) Space Flight Operations Facility (SFOF). Data and information flowed among the three facilities within the following six DSN Systems:

(a) Telemetry

(b) Tracking

(c) Command

(d) Monitor

(e) Simulation

(f) Operations Control

Details of the configuration of the DSN Facilities/Systems appear in Section III.

D. TDS Organization

The organization developed to manage TDS activities for MM '71 is shown in Fig. 1. Personnel involved in TDS activities had the following responsibilities:

(1) TDS Manager. JPL appointed a TDS Manager for MM '71, whose primary responsibility was to match requirements of the Project with the capabilities of the TDS facilities which provide support. His task was to organize and direct all cognizant agencies in accomplishing the evaluation, planning, and implementation of TDS capabilities to support the mission.

(2) Assistant TDS Manager. The Assistant TDS Manager for MM '71, who also served as the DSN Manager for MM '71, was directly assigned to the TDS Manager. He was responsible for the planning and implementation of DSN support and for the preparation of the DSN portion of the NASA Support Plan (NSP). In addition, he acted for the TDS Manager in the latter's absence, conducted critiques on DSN/MM '71 operations, recommended improvements to the DSN and changes to the Support Instrumentations Requirements Document (SIRD). He reported progress and conducted reviews on the DSN. He also provided interfaces between the DSN and other TDS agencies and directed the DSN/MM '71 Project Engineer (PE).

(3) TDS Coordinator for the Near-Earth Phase. The TDS Coordinator for the Near-Earth Phase was a representative of the JPL/AFETR Field Station at Cape Kennedy. He was responsible for integrating AFETR, MSFN, and DSN plans, testing, and operations as needed to conduct the TDS near-Earth phase.

(4) MSFN Coordinator. A MSFN Coordinator from the GSFC was the central point of contact between MSFN elements and other interfacing agencies. He was responsible for MSFN planning support and for assuring that compatible interfaces were established to make the MSFN function an integral part of the TDS in meeting Project requirements.

(5) AFETR Program Management Officer. The AFETR Program Management Officer was the single point of contact between AFETR elements and other interfacing agencies. He was responsible for AFETR planning support and for assuring that compatible interfaces were established to make the AFETR function an integral part of the TDS. He represented the AFETR at TDS meetings and Project meetings.

(6) DSN Project Engineer. The DSN PE coordinated all DSN systems and subsystems, working with representatives from numerous technical sections at JPL. He ensured that all systems interfaced in a compatible and timely fashion. He reported administratively to the DSN Engineering and Operations Section Manager, but was accountable at all times to the DSN Manager for MM '71 and, during mission operations, to the MM '71 Chief of Mission Operations (CMO).

The DSN PE directed and coordinated activities and served as Chairman of the DSN/MM '71 Interface Team. He maintained schedules reflecting DSN implementation, integration, training, operations, and documentation in support of MM '71. He planned and conducted acceptance tests, integration tests internal to the DSN and integration tests involving Project software, system verification tests, and training exercises. He compared required vs provided levels of DSN support, recommended changes in commitments, and audited operations.

(7) DSN Interface Team. Details of the interface design and operations planning were accomplished by the DSN/MM '71 Interface Design Team (Interface Team) under the technical guidance and coordination of the DSN PE for MM '71. The Interface Team, shown in Fig. 2, consisted of the DSN Facility PEs for the SFOF, GCF, and DSIF, as well as PEs and representatives for DSN operations, simulation, scheduling, and documentation.

E. Mission Objectives

1. General mission objectives. Mariner Mars 1971, a follow-on project to the Mariner 1964 and Mariner 1969 exploratory flyby missions, was planned as a 90-day Mars orbital mission designed to satisfy these general objectives:

(1) Broad topographical and thermal coverage of up to 70% of the planet's surface.

(2) Studies of seasonal variations of atmospheric composition, density, pressure, and temperature, and surface compositions, temperature, and topography. Changes in the measured parameters with time as well as with location were to be observed.

(3) Other long-term dynamic observations and experiments of opportunity: Martian satellites, Phobos/Deimos, stars, etc.

Mariner 1969 spacecraft design and equipment were used to the maximum possible extent,

although design of the MM '71 spacecraft incorporated those changes required to accommodate the payload, achieve Mars orbit, and achieve the necessary reliability for a nominal cruise and 90-day operational lifetime in orbit.

2. Scientific objectives. The scientific objectives of the MM '71 mission are discussed below.

a. Primary objectives. Primary scientific objectives of the MM '71 mission were as follows:

(1) Search for evidence of exobiological activity, or for the presence of an environment that could support exobiological activity on the planet Mars.

(2) Gather information that might provide answers to questions concerning the origin and evolution of the solar system.

(3) Collect basic scientific data related to the general study of planetary physics, geology, cosmology, and planetology.

b. Secondary objectives. Additional, secondary scientific objectives of the MM '71 missions included:

(1) Gathering data that would assist in the planning and design of future lander missions to Mars.

(2) Pursuing to the extent possible the general objectives of an extended mission of gathering scientific data available only after the 90-day orbital period; or extending measurements of phenomena having a time base in excess of 90 days; or repeating observations and measurements found to be of extreme interest during the 90-day mission.

3. Science experiments. A complementary group of science experiments, designed to study the surface features, the atmosphere, and the shape and mass distribution of the planet Mars from an orbiting spacecraft, was carried on the MM '71 spacecraft, as shown below:

Experiment	Instrument
Television	Television (TV)
Infrared Radiometry	Infrared Radiometer (IRR)
Infrared Spectroscopy	Infrared Interferometer Spectrometer (IRIS)
Ultraviolet Spectroscopy	Ultraviolet Spectrometer (UVS)
S-Band Occultation	None
Celestial Mechanics	None

a. Television experiment. The objectives of the television experiment were: (1) To investigate various Martian phenomena in order to achieve a more complete understanding of the dynamic characteristics, history, environment, and surface physiography of the planet, and (2) to obtain imagery suitable to developing better maps of the surface of the planet. The experiment was not expected to give direct information about the possibility of living organisms, but to give considerable indirect evidence of the suitability of Mars as a habitat.

A variable-features investigation provided a study of time-variable features on the surface and in the atmosphere of Mars to obtain information on atmospheric structure and circulation, details of seasonal and diurnal changes, and clues to the possibility of life on Mars.

A fixed-features investigation to map surface features over at least 70 percent of the planet was directed towards the following:

(1) Preparing an atlas covering the entire surface of Mars that had been successfully observed.

(2) Obtaining the broad range of image information for investigations of tectonic features, crater configuration and distribution, surface geologic features, and local surface environments.

(3) Investigating by photometric and photogrammetric analysis, surface slopes and elevation characteristics; determining surface brightness and albedo differences; and performing analysis related to improving the accuracy of the photometric function of Mars.

A secondary objective of the television experiment was to observe the Martian satellites Phobos and Deimos to obtain information on their shape and surface features.

b. Infrared radiometry experiment. The primary scientific objective of the infrared radiometry experiment was to investigate the following:

(1) Large-scale distribution of the thermal inertia of the surface materials.

(2) Occurrence of irregularities in the cooling curve or heating curve.

(3) Existence of hot spots that may indicate sources of internal heat.

(4) The absolute temperature of the south polar cap in order to differentiate between CO_2 and H_2O covers. Also, in view of the Mariner Mars 1969 results, the areal coverage of the cap with frost.

c. Infrared spectroscopy experiment. The basic scientific objectives of the infrared spectroscopy experiment were to provide spectral radiance measurements of thermally emitted radiation from the Martian atmosphere and surface to infer atmospheric and surface parameters. These parameters were then to be used in studies of the physical behavior of the atmosphere, investigation of the surface composition and structure, and biological processes. A major objective was to determine vertical temperature structure, composition (total atmospheric water content and

the variation of water vapor), and dynamics of the Martian atmosphere.

A further objective was to gather information on the types of surface materials present and to investigate possible biologic products by measurement of the temperature, composition, and thermal properties of the Martian surface, including the polar caps. It was important to derive these parameters as a function of latitude, local time, and gross surface irregularities (light and dark areas and a polar cap area).

d. Ultraviolet spectroscopy experiment. The objectives of the ultraviolet spectroscopy experiment were twofold:

(1) Ultraviolet cartography experiment to map the surface and lower atmosphere in the ultraviolet spectral region and investigate such phenomena as the wave of darkening, white and yellow clouds, and the blue haze/blue clearing. Implicit in the ozone measurements was the search for evidence of possible biologic activity in suitable micro-environments.

(2) Ultraviolet aeronomy investigations directed toward the following:

(a) Composition and structure of the upper atmosphere as a function of latitude, longitude, and time.

(b) Ionospheric composition and its variations.

(c) Distribution and escape rate of atomic hydrogen from the exosphere.

(d) Distribution and variability of possible ultraviolet aurora to explore a potential induced magnetic field on the planet.

A general objective of the experiment was to view the ultraviolet spectra of selected stars and continuously monitor the Lyman-Alpha intensity.

e. S-band occultation experiment. Objectives of the S-band occultation experiment were to provide information on possible variations in the properties of the atmosphere with latitude and season and to improve knowledge of the planet's shape. Measurements of atmospheric density and pressure at a large number of points above the surface would reinforce previous measurements, define possible variations with latitude, and provide data for the establishment of a circulation model for the atmosphere. Measurements of the ionosphere, performed with varying solar illumination, would lead to better understanding of the photochemical processes and reactions in the upper atmosphere.

f. Celestial mechanics experiment. The primary scientific objective of the celestial mechanics experiment was to obtain improvements in the kinematic map of the solar system. Information was to be gathered for studies in planetary physics and for studies of the origin of the solar system. Measurements were to be made to determine more accurate values of fundamental constants. Direct determinations of anticipated deviations from Newtonian theory (i.e., the general relativistic effects) would help to distinguish from among competing gravitational theories (e.g., Einstein vs Brans-Dicke). Determination of the geocentric distance to the center of Mars could be used by radar astronomers as a reference for Earth-based radar relay-time measurements, which could then be interpreted directly to yield topographical data. If within the design capability of the missions, other objectives were the following:

(1) To study the solar corona near the superior conjunction of Mars.

(2) To search for evidence of atmospheric drag effects on the Martian orbits of the spacecraft.

(3) To place a better bound on the total mass of asteroidal material.

(4) To estimate the masses of the outer planets.

4. Engineering objectives. There were three primary engineering objectives:

(1) To develop necessary equipment, software, strategies, and procedures for conducting orbital operations at planetary distance with two spacecraft simultaneously and demonstrate this capability. Orbital operation included insertion into Mars orbit; orbital trim; science data acquisition; engineering and science data transmission to Earth; orbital metric data acquisition; ground data handling, processing, and analysis; and spacecraft command and control in orbit.

(2) To develop and demonstrate the capability of conducting orbital operations in an adaptive mode whereby the data from one spacecraft revolution are used to influence the operation on subsequent revolutions. The adaptive mode was intended to provide for the enhancement of science data value and to permit full exploitation of experiments and targets of opportunity.

(3) To develop a mission design that provides the maximum degree of achievement of mission objectives, given a degraded spacecraft performance, and also allows enhancement of objectives, given better than nominal performance. This goal was to be met by two separate missions designed to acquire complementary sets of data. However, sufficient overlap was retained so that either spacecraft was capable of acquiring data to satisfy a minimum set of science objectives.

A secondary engineering objective was to extend spacecraft lifetime up to 1 year in orbit. To meet the primary objective of 90-day operation in orbit, design lifetime must be in excess of that required at orbit insertion plus 90 days. In addition to this, no design decision was made that precluded attainment of spacecraft design lifetimes on the order of one or more years in orbit.

An additional secondary engineering objective was to establish close functional relationships between system prelaunch activities and mission operations activities, especially between the spacecraft and Mission Operations System test activities and the orbital operations adaptive mode activities. This objective was realized by providing a one-to-one correspondence between equipment verification procedures and orbital operations procedures, permitting maximum use during mission operations of support equipment, software, techniques, skills, and expertise developed during preflight operations.

F. Mariner Mars 1971 Mission Plan

Implementation of mission objectives was the subject of the MM '71 Mission Plan. Mission characteristics were based on science experiment requirements constrained by systems comprised in the Project. Mariner 1964 and Mariner 1969 mission results indicated that Mars is not a homogeneous planet. Mariner 1964 results indicated a planet with a Moon-like surface; Mariner 1969 revealed, in addition, the polar cap and the Hellas region, devoid of craters. Hence, before an accurate idea of the origin and nature of the planet can be formulated, the entire surface of Mars must be investigated. Mission A of MM '71 was devoted to maximum-resolution surface coverage.

Since Earth-based and spacecraft observations indicate that Mars is a dynamic environment, a second objective was to examine the surface and atmosphere for seasonal and epochal changes. This implied a mission geared to extensive coverage at relatively high Sun angles since surface changes are best seen in the albedo and where the areas are investigated repeatedly under nearly identical conditions. Mission B of MM '71 was designed to investigate these variable features.

1. Mission A. For Mission A, orbit requirements were for high resolution and contiguous coverage. In selecting the orbital period, it was noted that an Earth-synchronous period would be desirable in order to place the view period for the Deep Space Communications Complex (DSCC) at Goldstone, California, at the optimal part of the orbit for data replay. Also, since the Goldstone view period was to be about 7 h long, it would be possible to replay two tape recorder loads of data (3 h each) per Goldstone pass or per 24 h. This immediately suggested a 12-h orbital period with two data-taking passes per day. In addition, the combination of the 12-h orbit and the 24-h, 37-min Mars rotation period meant that every other orbit would retrace its path across the planet except for a 9-deg longitude shift. The 9-deg shift, coupled with the 11 by 14-deg field of view of the TV subsystem, dictated a 1600-km minimum periapsis altitude (inclination-dependent) in order to get overlapping contiguous coverage. Hence, a 12-h direct orbit was selected with inclination between 70 and 80 deg to satisfy Sun occultation ΔV and Earth occultation requirements. To give optimal lighting conditions for the television experiment, a periapsis near the evening terminator was selected. This orbit would result in contiguous coverage of the planet with wide-angle TV from roughly -60 deg latitude to +40 deg north latitude with high-resolution TV and spectral data over the same region. The spacecraft would be over the south polar cap for inclinations of greater than 50 deg.

2. Mission B. Mission B required repeat coverage of the same area of the planet once or twice a week under nearly identical view conditions and high illumination angle. In addition, some full-disk global coverage was desired. An orbit with a period synchronous with Mars rotation was required to achieve repeat coverage, and one oriented such that the maximum illumination angle region would be between periapsis and apoapsis was needed to get higher area coverage. Hence, an orbit was selected with a period of 4/3 the Mars rotation period, which would yield repeat coverage over three sectors of the planet on 4-day intervals. The orbit was oriented with periapsis as close to the evening terminator as possible, subject to the ΔV constraint, to allow apoapsis over the lighted portion of the planet, thus achieving full-disk TV coverage. This placed the maximum illumination angle region about halfway between apoapsis and periapsis. The inclination would be about 50 deg, so that the southern hemisphere would be covered at maximum illumination and the Sun occultation constraint satisfied. Such an orbit would yield excellent coverage of the planet from -50 deg latitude to about +10 deg, at 45 to 50-deg solar elevation angles, with full-disk coverage of the planet from near apoapsis and high-resolution spectral data from near periapsis.

G. Launch Vehicle Description

The MM '71 launch vehicle consisted of an Atlas SLV-3C first stage and a Centaur second stage (Figs. 3, 4, and 5). It was basically the same launch vehicle that was used for the Mariner 1969 and Surveyor Projects.

The Atlas SLV-3C configuration had two main sections, the body or sustainer section and the aft or booster engine section. The vehicle was stabilized and controlled by gimbaling the engine thrust chambers. The propulsion system consisted of two booster engines, a sustainer engine, and two 2940-N (662-lb) thrust vernier engines. The combined thrust of all five engines was 1,794,248 N (403,383 lb). The engines used liquid oxygen (LOX) and kerosene (RP-1) as propellants. All five engines were in operation at liftoff. The Atlas telemetry subsystem transmitted functional and environmental data on a VHF carrier.

The Centaur stage is driven by two gimbal-mounted liquid hydrogen/liquid oxygen engines which provide a combined thrust of 130,000 N (29,200 lb). The same inertial guidance system which controlled the Atlas first stage also controlled the Centaur second stage. The second stage injects the spacecraft into its interplanetary trajectory in a direct ascent mode. The stage carries a VHF telemetry system and a C-band beacon for radar tracking.

H. Mariner Mars 1971 Spacecraft Description

The Mariner Mars 1971 spacecraft is a Mars orbiter that is fully attitude stabilized using the Sun and the star Canopus as basic attitude references. The design is based on Mariner technology and particularly on the Mariner Mars 1969

spacecraft. Changes of the Mariner Mars 1969 subsystem were made in operational life and performance capabilities to meet the requirements for the 1971 mission.

The MM '71 spacecraft configuration is presented in Fig. 6 (top view) and Fig. 7 (bottom view). Each spacecraft with its adapter weighed about 1010 kg at launch. Of this weight, 440 kg was usable propellant.

The MM '71 spacecraft is composed of 19 subsystems: four are science instruments, two directly support the science subsystems, and 13 contribute to the operation of the spacecraft as a semiautomated device. The features in the MM '71 design include:

(1) A three-axis attitude control subsystem with a high-accuracy auto pilot for maneuvers, orbit insertion, and orbit trims.

(2) A flight programmable central computer and sequencer with a 512-word memory.

(3) A 1334-N (300-lb) thrust propulsion subsystem capable of performing five maneuvers.

(4) An all-digital data storage and handling subsystem.

(5) A multiple-channel telemetry subsystem with variable high-rate telemetry.

(6) A two-way communication and command capability based on the use of a low-gain, a medium-gain, and a two-position, high-gain antenna.

(7) Four solar power panels, one battery, and power conversion equipment.

(8) Temperature control equipment.

(9) A ground-commandable two-degree-of-freedom scan platform for holding and pointing the scientific instruments.

(10) Planetary scientific instruments.

One of the most difficult aspects of the MM '71 mission is the reliability of operation during planetary orbit insertion. The design utilizes equipment and experience resulting from previous Mariner projects and in the utilization of state-of-the-art, thoroughly qualified equipment to the maximum extent practical.

The Mariner Mars 1969 design and equipment were adapted for use in the MM '71 spacecraft with a minimum modification restraint. Design modifications to the equipment were limited to changes required to achieve mission objectives and scientific goals.

1. Structures. Spacecraft structures are discussed below.

a. Configuration. The spacecraft after burning all usable propellants weighs about 544 kg (1,200 lb) and measures 2.286 m (7-1/2 ft) *to the top of the motor skirt and the low-gain* antenna. With solar panels extended, the spacecraft spans 6.90 m (22 ft, 7-1/2 in.) across. The octagonal structure is 127 cm (50 in.) across the flats.

The fuel tanks for the liquid bipropellant rocket propulsion subsystem are supported on top of the octagonal structure with the rocket nozzle protruding between the fuel tanks. Small gas jets are the actuating elements of the three-axis attitude control subsystem. The jets are divided into two duplicate sets for redundancy and are mounted on the ends of the solar panels.

Five of the electronics compartments in the octagon structure are temperature controlled by lightweight louver assemblies on the outer surfaces. Thermal shields cover most of the remaining area. The octagon interior is insulated by multilayer Mylar thermal shields at both the top and bottom of the structure.

The five instruments for the planetary experiments include the two TV cameras, the ultraviolet spectrometer, and the infrared radiometer and infrared interferometer spectrometer, all mounted on a scan platform below the octagon structure, which is described below.

b. Octagon structure. The Mariner octagon structure is a 18.12 kg (40-lb), eight-sided magnesium framework with eight electronic compartments. The electronic assemblies fastened within the compartments provide structural support to the spacecraft.

The eight compartments encircling the spacecraft contain the following equipment:

Bay I:	Power regulator electronics.
Bay II:	Power conversion, scan control, and IRIS electronics.
Bay III:	Attitude control and central computer and sequencer electronics.
Bay IV:	Command and telemetry electronics.
Bay V:	Data storage electronics.
Bay VI:	Radio electronics.
Bay VII:	Data automation and television electronics.
Bay VIII:	Battery.

The outboard surface elements of the major electronic compartments are designed to function as thermal/shear plates when mechanically integrated to the spacecraft primary structure.

c. Propulsion support structure. The propulsion support structure, a beryllium tube truss with magnesium fittings, is attached to the upper octagonal ring and supports the propulsion equipment, the two-position high-gain antenna, and the fixed low-gain antenna.

The magnesium alloy engine-thrust structure is attached to the titanium propulsion tank flanges *and locates the engine centerline on the spacecraft* axis. Tabs are fabricated on the tanks to

accommodate the truss members' attachment fittings. Motor alignment is made by adjustment of the gimbal actuators on the thrust plate. The thrust plate provides mounting surfaces and alignment for the engine gimbals, gimbal actuators, pyrotechnic valve manifolds, fuel feed plumbing, thermal shielding, and upper low-gain antenna attachments.

d. Antenna structures. The high-gain antenna structure consists of a reflector and a feed support truss. The reflector is an aluminum honeycomb parabola with a circular perimeter 101.6 cm (40 in.) in diameter. The feed is supported at the focus of the parabola by a fiberglass truss. The antenna is a two-position, pyrotechnically activated device that allows optimum pointing of the antenna toward the Earth during the pre-orbit and orbital periods.

The medium-gain antenna structure consists of a 10.16 cm (4-in.) diameter circular wave guide approximately 30.48 cm (1 ft) long with a frustrum-shaped reflector approximately 24.13 cm (9.5 in.) in diameter, mounted at its extremity with the flared end unsupported and oriented toward Earth during spacecraft orbit insertion.

The low-gain antenna structure is composed of a circular wave guide approximately 10.16 cm (4 in.) in diameter and 144.78 cm (57 in.) long with a frustrum-shaped reflector mounted at the extremity. It is supported vertically at the base by a bracket above Bay VI on the upper octagonal ring and is supported laterally by two truss members running between the low-gain antenna and the engine thrust structure.

e. Solar panel structures. Four solar panels for mounting of solar cells provide a total area of approximately 7.71 m^2 (83 ft^2). Each panel is 214 cm (84.2 in.) long by 90.17 cm (35.5 in.) wide. The cell surface substrate is a single skin on transverse corrugations supported by two cross-braced longitudinal spars.

The panels are supported during launch in a 15 deg-from-vertical position. Each panel is attached at the hinge points to panel support outriggers and is supported laterally at the tips by a pair of boost dampers running between adjacent panels.

The panels are opened after spacecraft separation by pin-pullers at one end of each boost damper pair and are deployed approximately 105 deg by a deployment mechanism. After deployment, the panels are latched in a plane normal to the spacecraft roll axis by engaging the attached damper mechanism.

f. Adapter structure. The MM '71 spacecraft is attached to the Centaur by means of an adapter structure. The spacecraft attaches to the adapter at the eight corners of the octagon by a V-band clamp. Pyrotechnic release devices in the V-band provide for structural separation of the spacecraft. The spacecraft adapter attaches to the Centaur adapter through a bolted field joint.

g. Meteoroid shield. A meteoroid shield is required for the propulsion module tanks. The design for MM '71 incorporates a tightly woven fiberglass cloth (i.e., Armalon) as the outer layer of the thermal insulation blanket. The tightly woven cloth is effective in breaking up the meteoroid particles. The Armalon cloth is spaced at least one-half inch from the propellant tanks by the thermal blanket.

A meteoroid shield of this type of construction will ensure adequate probability of no catastrophic puncture of the propellant tanks.

2. Mechanical devices. Mechanical devices include:

(1) Solar panel dampers.

(2) Solar panel deployment and latch mechanisms, including the switch assemblies for indications of deployment of panels.

(3) High-gain antenna deployment mechanism.

(4) Scan platform.

(5) Pyrotechnic arming switch (PAS).

(6) Spacecraft-initiated timer (SIT).

(7) Spacecraft separation mechanisms.

(8) Spacecraft V-band.

3. Power subsystem. The function of the MM '71 power subsystem is to generate, store, and convert all electrical power necessary for operation of the spacecraft. To perform this function, suitable switching, control, energy conversion, and power-conditioning functions are provided.

a. Solar panels. Primary spacecraft power is provided by the four photovoltaic solar panels. The panels convert solar energy to electrical energy when the sensitive surfaces are facing the Sun. Each panel is divided into six separate sections, each wired to deliver the rated solar panel voltage. The total panel area is 7.71 m^2 (83 ft^2) (800 W at Earth; 450-500 W at Mars).

The output of each panel section is connected to the main power bus through an isolating diode. The diodes prevent reverse current flow into the sections. A short in a panel section would cause a reverse current power drain on the system if there were no diodes.

The maximum solar panel voltage is limited to 50 Vdc by zener diodes that shunt the output of each solar panel section. This upper limit is functionally related to the voltage regulating action of the booster regulators in the power regulator subassembly.

b. Battery. Secondary spacecraft power is provided by a rechargeable nickel cadmium (NiCd) battery that supplies electrical energy during periods of non-Sun-orientation: launch-to-Sun acquisition, trajectory maneuvers, orbit insertion, and orbit trims.

The battery is capable of providing a minimum energy of 600-W/h. When not being used, the battery is kept on line and fully charged and is always ready to supply a backup source of power. The battery voltage range is nominally between

26.0-Vdc (discharged) and 38.0 Vdc (fully charged).

Two battery chargers supply either a high-rate or low-rate charge current to the battery during periods of Sun orientation. The battery chargers supply both high-rate and trickle charging currents (2 and 0.65 A) depending on the battery charge state. The amount of charge current is a function of the battery voltage and the dc power bus potential.

Boost converters relocate the main power bus operating point from a share mode to a solar-panel-only operating condition to prevent depleting the battery during transient or short-circuit conditions.

There are two booster regulators in the power subsystem. The regulators boost the bus voltage to a regulated 56 Vdc ±1%. The main booster regulator handles all spacecraft 56 Vdc power demands, and the standby booster regulator provides a backup. A booster regulator consists of four major parts: an input filter, an error amplifier, a transistor-controlled autotransformer, and an output filter.

4. Attitude control subsystem. The attitude control (A/C) subsystem provides spacecraft flight stabilization and orientation from the time of spacecraft separation from the Centaur vehicle throughout the duration of the mission. The spacecraft references needed for attitude control are sensed by inertial (three single-axis gyros) and optical (Sun, star) sensors. Attitude control logic electronics process the reference sensor outputs along with other information such as Central Computer and Sequencer (CC&S) or radio command signals to generate the necessary control signals for use by the vehicle control elements to stabilize and orient the spacecraft, as required.

The spacecraft contains two attitude control gas assemblies. The gas supply and regulator of each assembly is mounted on the top ring of the octagon with the gas jets mounted on the tips of the solar panels. The required plumbing between the jets and manifolds attaches to the octagon and solar panel structures.

a. Sun sensor. The cruise and acquisition Sun sensors are the position sensing elements in the pitch and yaw cruise attitude control loops. The acquisition sensors are positioned on the end of the solar panels so that the Sun will always be visible to at least one set of sensors during acquisition. The cruise Sun sensor is mounted on one of the outriggers which support the solar panels.

A Sun sensor consists of a photoresistor mounted beneath a shadow mask. The sensors are connected in pairs so that the output is a dc signal that is approximately proportional to the angular deviation of the sensor axis from the line-of-sight to the Sun, within certain limits.

b. Sun gate. The Sun gate is used to determine when the spacecraft has acquired the Sun. Prior to Sun acquisition, the Sun gate signal functions are:

(1) Holds the power onto the acquisition Sun sensors and the gyros.

(2) Enables Sun shutter power to the Canopus sensor.

(3) Inhibits the Canopus sensor roll error signal.

(4) Inhibits the CC&S cyclic adaptive gate signal.

(5) Inhibits the boost converter in the power subsystem.

c. Canopus sensor. The Canopus sensor is the position sensing element in the roll attitude control loop and is located on the upper ring structure of the octagon, between solar panels, for a clear field of view. It consists of an image dissector tube with a photocathode surface and the associated electronics. Light input to the surface of the tube is converted to an output roll error signal for spacecraft roll attitude control.

A mechanical Sun shutter protects the Canopus sensor from the damaging effects of very bright objects such as the Sun when the Sun is within the field-of-view of the Canopus optical axis.

d. Autopilot. The function of the autopilot is to maintain attitude control of the spacecraft during the firing of the rocket motor, for the long orbit insertion burn, and for the relatively short orbit trim and trajectory correction maneuvers. This is accomplished by mounting the engine in a gimbal system: control of the engine thrust vector is accomplished by two linear actuators; the gimbal actuators extend and retract a few millimeters, rotating the engine in its gimbal system. This engine rotation capability allows the autopilot system to point the thrust vector through the spacecraft center of mass and maintain attitude stability in pitch and yaw. The exhaust gases will produce some torque about the Z axis, requiring an additional control system for roll stability. The gas jets are used for roll control during the motor burning period.

A signal from the linear accelerometer/CC&S combination will cause engine shutdown when the required spacecraft velocity change (ΔV) magnitude has been reached. At this point, the motor burn switch disables path guidance control and restores the normal pitch and yaw deadbands.

5. Scan control subsystem. The scan control subsystem provides precision angular control of the two-degree-of-freedom (clock and cone axes) gimballed support structure or platform (scan platform) upon which all the science instruments are mounted.

The scan control subsystem operates in the following modes: preorbit TV, orbital science and orbital cruise. In the pre-orbit TV mode, the platform is slewed so that a series of spaced TV pictures pairs can be taken of the planet from a distance. In the orbital science mode, the platform is sequenced through a series of pointing directions. The scan pointing positions are programmed in flight and during the orbital sequence by CC&S commands or radio quantitative

commands (QC). In the orbital cruise mode, the scan subsystem is turned off and the platform, if unlatched, is slewed to the stow position where it remains until maneuvers are terminated.

Four reference potentiometers contain the nominal clock and cone angles for the start of both the pre-orbit and orbital science sequences. The reference potentiometers are coupled through a gear train to stepper motors. One revolution of the stepper motor turns the platform one-fourth degree.

Two identical clock and cone sequencing circuits supply pulses to turn the energized step motor. In a typical scan operation, the sequencing circuits receive either clockwise or counterclockwise pulses spaced 1 s apart from either the flight command subsystem or CC&S.

At launch, the scan platform is secured in the stowed position. During the pre-orbit TV sequence, a CC&S event or direct command signals the pyrotechnic subsystem to unlatch the scan platform.

6. Central computer and sequencer subsystem. The central computer and sequencer subsystem is required to provide timing and sequencing services to other spacecraft subsystems. These functions are generated by a special purpose programmable computer and a fixed sequencer for redundancy in the maneuver mode.

Timing and sequencing (excepting the fixed sequencer) are programmed into the CC&S prior to launch and can be modified during flight by transmitting coded commands. The CC&S is programmed to execute various standard or anticipated flight sequences and to produce numerous specific CC&S output events. The six basic sequences for which the CC&S initiates timed events are launch, cruise, maneuver, pre-insertion, orbit insertion maneuver, and orbit trim maneuvers.

Trajectory correction maneuvers (including orbit trim), in the normal operating mode, are fixed in sequence with roll, yaw directions and spacecraft velocity increments variable by coded command. The normal operating mode, defined as the tandem mode, operates the computer portion of the CC&S concurrently with the fixed sequencer and requires that events coincide between each portion or an abort will result within the CC&S.

The "sequencer only" mode is prime for the orbit insertion maneuver, with selected backup functions performed by the computer.

7. Pyrotechnics subsystem. The spacecraft design employs a number of squib (electro-explosive) actuated devices such as solar panel release latches, scan platform latches, propulsion system valves, etc. The pyrotechnic subsystem accepts commands from the appropriate sources and provides the energy necessary to fire the proper squibs.

Pyrotechnic functions include:

(1) Spacecraft V-band release (the launch vehicle supplies power).

(2) Solar panel deployment.

(3) Scan platform release.

(4) Propulsion squib valve actuation (15 valves).

(5) High-gain antenna position update.

(6) Propulsion solenoid valves power switching.

8. Temperature control subsystem. The four major variables affecting temperature of spacecraft components are incident solar radiation, electrical power expenditure, thermal transfer between components, and thermal radiation of the spacecraft into space. Various devices, both passive (shields, thermal blankets, paint, polished surfaces) and active (variable-emittance louver assemblies) are used by the temperature control subsystem.

Multilayer thermal blankets are employed on both the sunlit (top and bottom) sides of the spacecraft. Both blankets are lightweight, adiabatic boundaries. The purpose of the top blanket is to isolate the propulsion module and bus from the Sun; the bottom blanket minimizes thermal gradients within the bus from top to bottom and forces the internally dissipated power to be rejected to space through the louvered bay faces.

Temperature control louvers are installed on all of the spacecraft bays except Bays III, IV and VI. Bay III and IV are covered with polished, low-emittance aluminum shields, and Bay VI, housing the radio, with high-emittance white paint.

9. Radio frequency subsystem. The radio frequency subsystem (RFS) receiver is a narrow band, double superheterodyne with automatic phase control, operating continuously at a frequency of 2115 ±5 MHz. When locked to a signal transmitted from the DSIF stations, the receiver controls the phase and frequency of the transmitter radio frequency (RF) carrier, demodulates the composite command signal, if present, supplies this to the flight command subsystem, and also demodulates the ranging signal, if present.

The RFS transmitting equipment consists of dual redundant RF exciters and two redundant traveling wave tube power amplifiers (TWTAs). Each exciter contains a crystal oscillator which is the frequency source of its output signal when the receiver is not locked to an up-link signal from the DSIF. When the receiver is locked to an up-link signal, the receiver voltage-controlled oscillator (VCO) is used as the frequency source of the output signal. Each exciter can modulate the RF signal with (1) the telemetry signal from the FTS subsystem and (2) the detected ranging signal when the ranging channel is on. The exciters operate at a fixed frequency of 2295 ±5 MHz, and the transmitted RF power output level can be either low power (10 W) or high power (20 W).

10. S-band antenna subsystem. The radio frequency subsystem uses three S-band antennas. The two-position high-gain antenna, a 101.6-cm (40-in.) parabolic reflector with a right-hand circularly polarized feed, is used for transmitting before and during orbit. The antenna operates at

the frequency of 2,295 ±5 MHz. The antenna can be oriented to a second position during the orbital period to maximize communication time in orbit.

The fixed low-gain antenna, also circularly polarized, is mounted on the sunward side of the spacecraft and has a hemispherical pattern approximately symmetrical about the roll axis. It is used to receive and to transmit when the high-gain antenna cannot be used and provides forward hemispheric coverage. It operates in the frequencies of 2,115 ±5 MHz and 2,295 ±5 MHz.

The medium-gain antenna is a right-hand circularly polarized radiator and provides coverage during the orbit insertion maneuver. The antenna is coupled to the low-gain antenna and operates in the same frequency range.

11. Flight command subsystem. The flight command subsystem (FCS) receives a subcarrier signal from the radio frequency subsystem which has been modulated by the desired command word sent from Earth.

Each command word consists of a specific coded sequence of 26 bits which, when decoded by the subsystem, causes the desired remote control action of the spacecraft. It takes 26 s to receive one complete command word.

There are three basic types of command words:

(1) Direct commands (DC), which cause immediate spacecraft responses as soon as the 26th bit is received. Eighty-two different operations may be commanded by DCs.

(2) Quantitative commands (QC), which step the scan platform reference angles.

(3) Coded commands (CC), which (1) update the Central Computer & Sequencer program and (2) instruct the data automation subsystem to deviate from its nominal timing, sequencing, and controlling of the science payload.

12. Data automation subsystem. The data automation subsystem (DAS), acts as the signal interface between the scientific instruments and all other subsystems of the spacecraft. The DAS controls and synchronizes the science instruments, samples, converts, and buffers data from the instruments, and transmits the data in proper formats to the flight telemetry and data storage subsystems and to both the CC&S and the FCS.

Changes to the Mariner Mars 1969 DAS necessary to make a suitable DAS for the MM '71 result from the orbiting nature of the mission and from the changes in the data storage subsystem. On the Mariner Mars 1969 flyby, the sequence of operations during encounter was primarily controlled by sensing the relationship of the spacecraft to the planet through the planet-in-view and narrow-angle Mars gate signals. The MM '71, by the nature of the mapping sequence, cannot obtain control information directly and must be controlled by the central computer and sequencer, which will be programmed from Earth. Relatively minor interface changes were required in the DAS to place it under the control of the CC&S.

More extensive changes to the DAS were required to make it compatible with the new all-digital data storage subsystem.

13. Flight telemetry subsystem. The flight telemetry subsystem (FTS), by suitable modulation of the radio subsystem RF carrier, enables the transmission of spacecraft data. The FTS provides dual-channel modulation consisting of an engineering channel and a science channel.

a. Engineering channel. Engineering data consists of the 94 measurements that are required to monitor the performance of the spacecraft as follows:

(1) Analog voltages of various spacecraft equipment parameters--temperature, pressure, currents, voltages, etc.

(2) Digital words indicating spacecraft equipment status, and counts of events or elapsed times.

Analog voltages are converted into 7-bit non-return-to-zero (NRZ) data prior to data processing. Engineering data is transmitted at 33-1/3 or 8-1/3 bits/s.

Data from the central computer and sequencer memory may be read out in lieu of engineering data as a special operational submode of the engineering channel.

b. Science channel. Science data consists of all the data processed by the data automation subsystem and includes the measurements made by the science instruments and measurements made to monitor the performance of the instruments and the DAS. Transmitted science data consists of the following (depending upon the selected FTS mode of operation):

(1) Real-time science data at 50 bits/s.

(2) Block coded real-time science data at 16 or 8 kilobits/s.

(3) Block coded stored science data playback from the data storage subsystem at 16, 8, 4, 2 or 1 kilobits/s.

14. Data storage subsystem. The purpose of the data storage subsystem is to record the TV and other science data at 132 kilobits/s and play back this data at a time and rate compatible with the communication link to Earth. The data storage system stores 1.8×10^8 bits of information on 168 m (550 ft) of 1.27-cm (1/2-in.) magnetic tape. Four tape passes are required to fully load (or unload) the data storage subsystem. The playback rates are 16, 8, 4, 2 and 1 kilobits/s.

The data storage subsystem operates in 4 modes:

(1) Ready — power is applied.

(2) Record — data is recorded at 132.3 kilobits/s.

(3) Playback – data is played back.

(4) Slew – the tape may be rapidly moved to one end or the other upon command.

The 16 and 8-kilobit/s rates will be used when the playback is to the 64-m (210 ft) diameter antenna, and the 2 and 1-kilobit/s rates will be used when only the 26-m (85-ft) diameter antennas are in operation.

15. Propulsion subsystem. The propulsion subsystem utilizes a 1334-N (300-lb) thrust rocket engine to provide accelerometer-controlled impulse to the spacecraft to accomplish: (1) in-transit trajectory corrections, (2) deceleration of the spacecraft into orbit about Mars, and (3) adjustments to the orbit as required.

The propulsion module is designed to be an entity, with truss members and ring sections tying the tanks, pressure vessels, and associated valving together. The module structure is integrated with a bridge, box-section between tanks to support the engine, gimbals, and related plumbing.

Two unique features are incorporated into the design to assure leak-tightness of the system during its long storage in space. All but four tubing joints are permanently made with brazed fittings, and positive isolation of propellants and pressurant is provided through the use of squib-operated valves. The use of squib valves reflects the technology developed on past Mariner series spacecraft. Propulsion subsystem characteristics are as follows:

Engine thrust	1334-N (300 lb)
Fuel	Monomethyl hydrazine
Oxidizer	Nitrogen tetroxide
Flow rate	480 g/s (1.06 lb/s)
Oxidizer/fuel ratio	1.50
Propellant capacity	462 kg (1020 lb)
Specific impulse	283 kg-s/kg

The rocket engine burns a liquid fuel and oxidizer, each of which is stored in a 76.2-cm (30-in.) diameter titanium tank. Gaseous nitrogen, stored at 27.6×10^6 N/m^2 (4000 psi) in the two smaller titanium tanks, is regulated to 1.83×10^6 N/m^2 (265 psi) to force the propellants into the engine.

The rocket engine assembly consists of (1) an electrically operated bipropellant valve, (2) an aluminum injector to mix the propellants, (3) a beryllium thrust chamber to contain the hot gases during their burning, (4) a cobalt-alloy conical nozzle to accelerate the gases, and (5) associated mounts and bearings so that the assembly may be swiveled in two planes by the gimbal actuators.

I. Science Payload Characteristics

Since the two spacecraft were interchangeable, both Missions A and B used identical instruments, as follows:

(1) Television camera A.

(a) Rectangular 11 by 14-deg wide-angle field of view.

(b) Exposure time controlled either by on-board logic (DAS exposure algorithm) or ground command.

(c) Eight-position filter wheel with the filter cycled automatically through even position 2 through 8, or set by ground command.

(d) Each picture composed of 700 lines, each having 832 picture elements (pixels) per line. The brightness of each element was encoded to a 9-bit resolution.

(e) Data recorded in DSS for delayed playback. Also, selected data transmitted in real time in selected video format of 16.2 kilobits/s.

(2) Television camera B.

(a) Rectangular 1.1 by 1.4-deg narrow-angle field of view.

(b) Exposure time controlled either by on-board logic (DAS exposure algorithm) or ground command.

(c) Single fixed filter.

(d) Each picture composed of 700 lines, each containing 832 picture elements (pixels) per line. The brightness level of each element was encoded to 9-bit resolution.

(e) Data recorded in the DSS for delayed playback. Selected data can be transmitted in real time in selected video format of 16.2 kilobits/s.

(3) Infrared interferometer spectrometer.

(a) Circular field of view with full 4.5-deg cone angle.

(b) Equivalent output data rate, 2.7 kilobits/s.

(4) Infrared radiometer.

(a) The instrument can detect two channels of sensitivity: (1) Channel 1 square, 0.53 by 0.53-deg field of view, sensitive to 8 to 12-μm wavelengths, and (2) Channel 2, equipped with a square 0.7 by 0.7-deg field of view, sensitive to 18 to 25-μm wavelengths.

(b) Equivalent data rate from both channels, 16-2/3 kilobits/s.

(c) Data transmitted in real time in orbital science format of 50 kilobits/s. The format was encoded in the high-rate, real-time science formats and in recorded data format.

(5) Ultraviolet spectrometer.

(a) The instrument consists of two detectors: (1) a square, 0.25 by 0.25 deg, and (2) a slit, 0.25 by 2.50 deg.

(b) Equivalent data rate from both detectors, 3.6 kilobits/s.

(c) Data recorded in the DSS for delayed playback or transmitted in real time in the spectral science format of 8.1 kilobits/s.

(d) Data samples in the Lyman-Alpha range obtained at the equivalent rate of 3.8 bits/s, and transmitted in real time in the orbital science format of 50 bits/s. Also, this format encoded in the high-rate, real-time science and recorded data formats.

(6) Celestial mechanics and S-band occultation experiments. No unique instruments are required for the S-band occultation experiment and for the celestial mechanics experiment, each of which uses the spacecraft radio link to achieve its objectives.

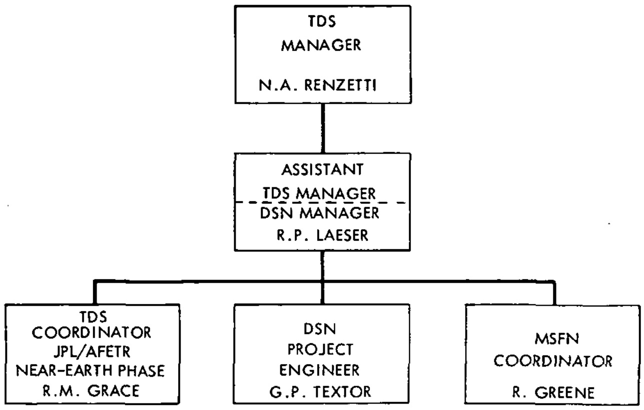


Fig. 1. TDS organization for Mariner Mars 1971

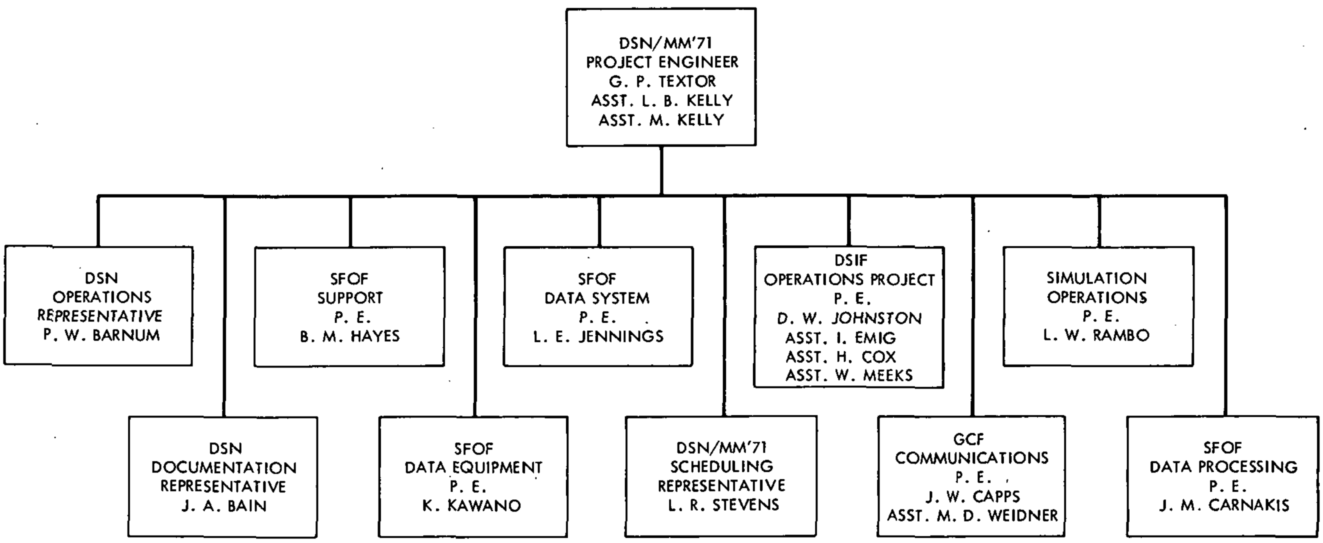


Fig. 2. DSN project engineering organization for Mariner Mars 1971

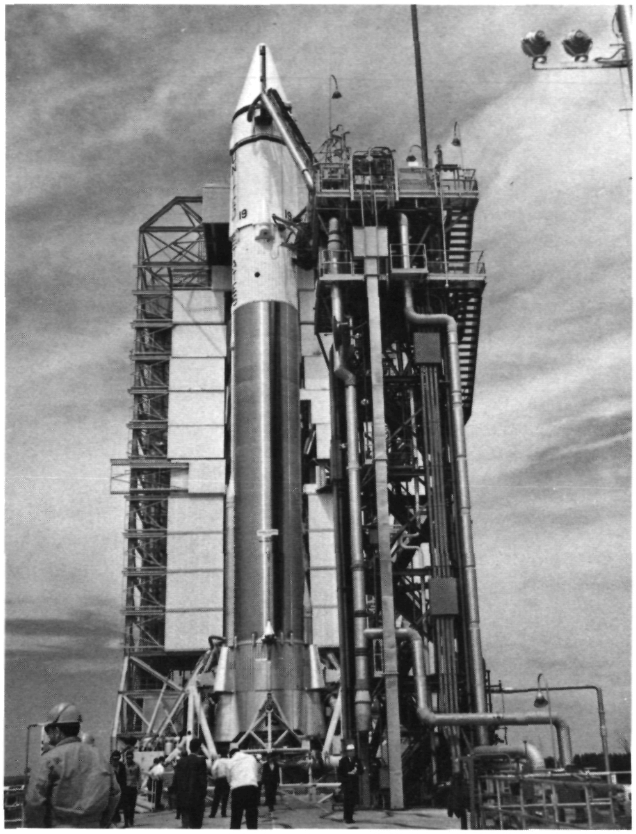


Fig. 3. Atlas/Centaur launch vehicle on pad

Fig. 4. Atlas/Centaur launch vehicle during blastoff

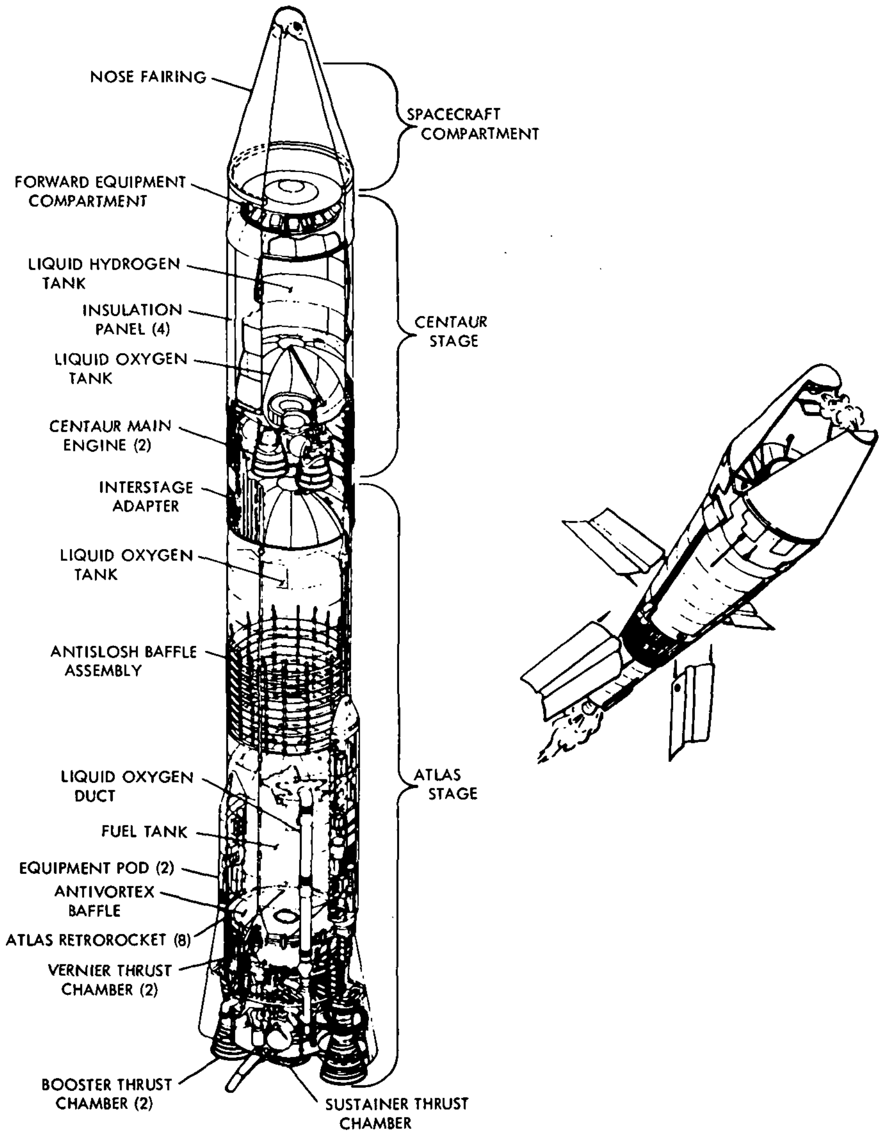
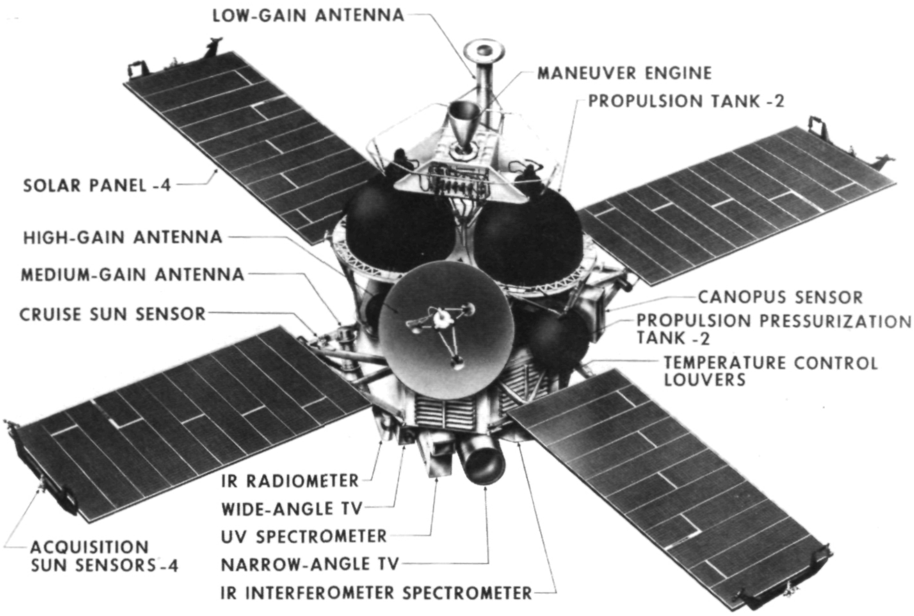
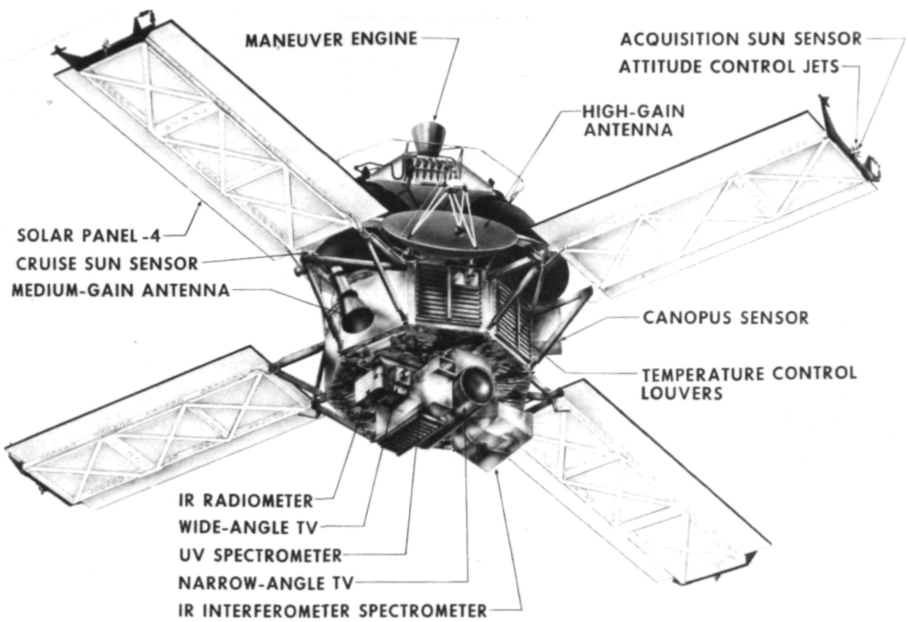


Fig. 5. Atlas/Centaur launch vehicle (schematic)



NOTE: PROPULSION MODULE AND SCAN PLATFORM INSULATION BLANKETS NOT SHOWN

Fig. 6. Mariner Mars 1971 spacecraft configuration, top view



NOTE: PROPULSION MODULE AND SCAN PLATFORM INSULATION BLANKETS NOT SHOWN

Fig. 7. Mariner Mars 1971 spacecraft configuration, bottom view

II. PROJECT TRACKING AND DATA ACQUISITION REQUIREMENTS

A. General

Tracking and data acquisition is defined as acquisition, transmission, and processing of information that enables determination of space vehicle position, velocity, direction, system, and subsystem performance, and experiment measurements, all with respect to a common time base.

All project requirements on the TDS were placed in the Support Instrumentation Requirements Document for MM '71 and in subsidiary documents called out in the SIRD. A NASA Support Plan was prepared to respond to the SIRD. This Section presents the primary requirements, and Section III presents the primary elements of the plan, for all phases of the planned mission. Subsequent volumes of this Technical Memorandum will cover only the updates to the requirements and plan which have occurred after the time period covered in the previous volume.

The near-Earth phase began with prelaunch activities and continued through launch until the spacecraft would be in continuous DSN view. At this point, the deep-space phase began, and it continued to the end of the mission. Material in this section is organized to follow this division of the requirements.

B. Near-Earth Requirements

1. Launch phase coverage. The Project required TDS to plan to support a launch period from May 3, 1971, to June 9, 1971, with a launch window each day of about 1 h. Figure 8 shows a general correlation of near-Earth TDA requirements with flight profile.

The MM '71 Project included the launching of two spacecraft to orbit the planet Mars. It was planned to launch Mission A first and Mission B second. The two spacecraft were to be launched by the Atlas/Centaur launch vehicles from launch complexes 36A and 36B at AFETR. Figure 9 shows the Atlas/Centaur launch vehicle for MM '71. Table 1 is a summary of launch vehicle frequency utilization. Tables 2 and 3 give general information, and transmitter and antenna characteristics of Atlas and Centaur telemetry links, respectively. Inertial guidance data are presented in Table 4. Two launch pads were required to permit a turnaround time of 10 days between launches. Launch azimuths were to be between 81 and 108 deg. The space vehicles were to be launched employing a direct ascent mode for attaining the Earth-Mars transfer trajectory required by the spacecraft. A constant launch azimuth was designated for each targeted launch day. Because of unusually favorable launch geometry peculiar to MM '71, only a relatively small amount of yawing was required by the launch vehicle in conjunction with the daily fixed launch azimuth in order to accommodate the varying geometry during any launch window. Minimum injection altitude was 166.7 km (90 nmi) (Fig. 10). The trajectory profile is presented in Fig. 11 to show events vs time T + 0 through T + 1964 s, or main engine cutoff (MECO) + 1250 s.

a. Flight trajectories. The MM '71 trajectory design was somewhat different from previous Mariner missions. For the MM '71 mission design, the concept of launching from the target antipode was used. Launching from the target antipode was accomplished when the launch position vector and the negative of the geocentric escape asymptote were almost aligned. To align the escape asymptote, a small amount of yawing during the powered flight ascent trajectory was performed.

This trajectory design had two major impacts on the near-Earth trajectory characteristics. First, the launch azimuth (AZ) for any given day was held because the launch vehicle performance was rather insensitive to the launch azimuth. Secondly, the powered flight trajectories were nonplanar because of the small amount of left or right yaw steering during the powered flight phase.

Earth tracks and launch dates (LD) for the two prime arrival dates (AD) of November 14 and 24, 1971, are shown in Fig. 12. Earth tracks for two cases for each arrival date, which bounds launch azimuths, are shown thus:

LD, 1971	AD, 1971	AZ, °
5 May	14 Nov	86.0
15 May	24 Nov	102.3
27 May	14 Nov	93.4
4 June	24 Nov	86.0

The flight path angle at injection was negative at the opening of the window for many launch days, but in all cases the path angle becomes progressively more positive during the daily launch window. Changes in path angle vs daily launch time are shown in Launch Time Dependent Trajectory and Performance Data for Mariner '71 Missions, Report GDC-BKM-70-001, General Dynamics/Convair, San Diego, California, Jan. 1970. Negative path angles at the opening of the window were not the shortest tracking intervals for certain near-Earth tracking stations, however. In many cases, this occurred a few minutes into the daily launch window where the path angle was near zero. The altitude at injection is minimum when the path angle is near zero. (See Fig. 10 for the relationship of injection flight path angle to injection altitude.)

b. Launch days and flight events. The MM '71 launch period for the arrival dates of November 14 and 24 opened on May 5 for launching the Mission A spacecraft and closed on June 4 for launching the Mission B spacecraft.

Mission A, arriving on November 14, could have been launched on May 5 through June 3. The launch azimuth on these days varied from 105.95 to 91.34 deg; the launch azimuth remained constant throughout any given day. Most of the windows were approximately 1 h. On May 5, 6, 7, and 8, the windows were shorter, however, being closer to 30 min.

The Mission B launch period was from May 15 through June 4. The launch azimuth for this

period varied from 93.98 to 85.92 deg. Most of the daily launch windows were over 1 h.

Key flight events for the near-Earth phase of both missions are listed in Table 5.

2. Near-Earth TDS requirements. Since the near-Earth TDS requirements were given in detail in the MM '71 Support Instrumentation Requirements Document and Program Requirements Document, they are only summarized here. For convenience, data requirements have been separated into three types: metric data (C-band and S-band), launch vehicle telemetry, and spacecraft telemetry. Project requirements are listed in Tables 6, 7, and 8, respectively.

Using the overall tracking coverage data provided as indicated in Table 6, the AFETR Real-Time Computer System (RTCS) was to provide the following:

(1) Transfer of orbit elements, IRV, and Mars mapping based on C-band tracking data after injection.

(2) DSIF predicts for DSS 51, DSS 62, and the MSFN ACN site, based on the orbital elements above.

(3) Mars mapping based on Centaur guidance telemetry data after injection.

(4) Spacecraft orbital elements, Mars mapping, and I-matrix based on S-band tracking data after separation.

(5) DSIF predicts to DSS 51, DSS 62, and the MSFN ACN site, based on the spacecraft orbital elements above.

(6) Centaur postdeflection orbital elements, Mars mapping, and I-matrix based on C-band tracking data after deflection.

(7) Mars mapping based on Centaur guidance telemetry data after deflection.

3. Data uses. Information on the nature and use of the data obtained helped clarify Project requirements. There were five major uses:

(1) Establish as quickly as possible the normalcy of the mission.

(2) Determine minute-by-minute status of the flight.

(3) Aid the DSN, MSFN, and AFETR stations to acquire the vehicle or spacecraft.

(4) Aid Project decisions concerning a nonstandard mission.

(5) Enable postlaunch analysis.

Requirements for metric and telemetry data support were divided into classes by the Project Office according to their importance with respect to successful accomplishment of the mission. These classes are defined as:

Class I: Requirements that reflect minimum essential needs to ensure accomplishment of primary test objectives. These were mandatory requirements that, if not met, might result in a decision not to launch.

Class II: Requirements that reflect the needs to accomplish all stated test objectives.

Class III: Requirements that reflect the ultimate in desired support. Such support should provide capability to achieve test objectives earlier in the test program.

4. Communications. Project communications requirements in the near-Earth phase were for data and voice channels within the elements of the TDS and among TDS facilities and the Project launch operations facilities, adequate to conduct test and launch operations. Ground Communications Facility requirements as presented in the Support Instrumentation Requirements Document for MM '71 included voice nets, high-speed data (HSD), wideband data, and teletype. Locations of GCF operating terminals for the near-Earth phase were required at the Space Flight Operations Facility, at CTA 21, at the Simulation Center, and at the Spacecraft Assembly Facility, for JPL, and at Building AO, Cape Kennedy Air Force Station (TCF); DSS 71, Real-Time Computer System; Building AE (MDC); Goddard Space Flight Center (Manned Space Flight Network Operations Control); Kennedy Space Center Central Information Facility; and Complex 36, for the AFETR.

C. Deep Space Phase Requirements

1. Deep space phase coverage. Project requirements for TDS support during the deep-space phase were divided according to flight sequence as shown in Table 9. Continuous coverage was required during launch, acquisition, first trajectory correction maneuver, second trajectory correction maneuver, orbit insertion, and orbit. During cruise, the requirement was for telemetry data often enough to detect any spacecraft problems and take corrective action.

a. Radio metric (tracking) data. Radio metric data requirements included (1) angle data taken during the initial mission phase, but later omitted, and (2) range in two-way doppler, required throughout all mission phases. Data were acquired in real time, except that the 1-sample/second rate during critical phases was displayed on printers and plotters in the SFOF and recorded on magnetic tape. During cruise, or noncritical phases, radio metric data were required to be recorded on magnetic tape and to be immediately available if needed. All radio metric data received in the SFOF in real time were required to be displayed on printers.

The detailed tracking requirements are presented in two tables: spacecraft tracking requirements are listed in Table 10; spacecraft tracking accuracy requirements are listed in Table 11.

b. Telemetry data. Requirements for spacecraft telemetry data acquisition are listed in Table 12. Mariner Mars 1971 required combined spacecraft telecommunications, ground

telecommunications, and ground communications system to provide the telemetry accuracy indicated in Table 13. The TDS was required to provide ground reception and communication capability to meet these requirements, consistent with the defined spacecraft.

2. Ground communications (Project requirements). Project requirements for ground communications are presented in Table 14.

3. Ground command requirements. Starting at launch + 1 h, command capability was required during any phase of the mission. The command system required use of the Multi-Mission Command System (MMCS) provided and maintained by the DSN. Time to execute commands was not to exceed 30 s from entering a command to the MMCS to the start of transmission from a DSS. Requirements for command coverage included the following:

(1) Launch + 1 h to encounter - 7 days of 1st spacecraft. Continuous command capability to one spacecraft, the one spacecraft to be selectable.

(2) Encounter - 7 days of 1st spacecraft to end of mission.

   (a) Continuous command capability to both spacecraft while over the Goldstone DSCC.

   (b) Continuous command capability to one spacecraft, the one spacecraft to be selectable while not over Goldstone.

4. Simulation. The DSN was required to provide a simulation capability which the Project assumed was to be provided by the DSN Simulation Center (SIMCEN) a primary element of which was an ASI 6050 computer. The SIMCEN was required for the generation of simulated spacecraft telemetry and radio metric (tracking) data during computer program (facility) testing, DSN system testing, mission operations testing, and data flow tests.

By means of mission operational functional requirements, the Project required a DSN capability to simulate simultaneously two operating spacecraft in the cruise mode as well as one in the cruise mode and one in a critical phase such as launch, maneuver, encounter, or nonstandard condition. The Project was to provide realistic spacecraft data to the SIMCEN. The simulation system was required to be capable of inserting simulated data at various points in the data system, including each prime tracking station. Ground communications for simulation support required for all phases of the mission, as found in the SIRD, are presented in Table 15.

5. Mission support areas. Floor space and beneficial occupancy dates (BOD) requirements for Mission Support Areas (MSA) are given in Table 16.

6. Compatibility testing. Support from the TDS was required to design, plan, and conduct RF and data compatibility tests between the spacecraft and TDS facilities. Project based this requirement on the assumed availability of the DSN Compatibility Test Area (CTA) 21 at JPL. This capability was required to perform telecommunications subsystem tests and computer program checkout.

Table 1. Summary of launch vehicle frequency utilization

ITEM NO.	TEST CODE	FREQUENCY MHz	EMISSION CHARACTERISTICS	PURPOSE	PROTECTION REQUIRED kHz	EST. TIME OF USAGE[a]		SPECIAL MONITORING REQUESTS
						PRE-OP.	LAUNCH	
1	All	2215.5	PAM/FM/FM 500 F9, 10 w	Atlas TLM No. 1	±500	4	6.5	NOTE: Estimated time of usage includes 6 hours during countdown; remainder is estimated in flight time.
2	All	2202.5	PAM/FM/FM 500 F9, 10 w	CENTAUR TLM	±500	4	10.5	
3	All	5765	5000 P9, 1 w (average) 500 w (peak)	C-Band Radar Tracking, Beacon Reply	±150	4	10.5	
4	All	414	300 F9, 10 kw (peak)	Command Destruct	±150	4		
5	All	414	300 F9, .001 w	RSC Checkout	±150	4		

[a] In hours

Table 2. Atlas telemetry link

GENERAL INFORMATION

A. TEST CODE: All

B. NUMBER OF CHANNELS: 18

CONTINUOUS: 13

COMMUTATED: 5

C. NUMBER OF SEGMENTS/CHANNEL:

CHANNEL	SEGMENTS
11	60
13	60
15	60
16	60
18	60

D. STATE NON-IRIG PARTICULARS:

None

TRANSMITTER CHARACTERISTICS

A. LOCATION: First STAGE

B. TYPE: FM

C. MODEL: CTM-UHF-30F (GDC 55-01352-3)

D. MANUFACTURER: Conic

E. LINK FREQUENCY: 2215.5 MHz

F. TYPE OF MODULATION: PAM/FM/FM

G. BANDWIDTH AT 3DB: 0.15 MHz

H. BANDWIDTH AT 60DB: 0.65 MHz

I. IS THE ASSIGNED FREQUENCY MEASURABLE IN THE MODULATED LINK RF SPECTRUM?

[X] YES [ ] NO

J. IF I ABOVE IS NO, LIST A MEASURABLE CHARACTERISTIC FREQUENCY: N/A

K. INDICATE THE FIXED DIFFERENCE FROM ASSIGNED FREQUENCY: N/A kHz

L. MINIMUM DEVIATION: 0 kHz

M. MAXIMUM DEVIATION: ±400 kHz

N. FREQUENCY STABILITY: ±66.2 kHz

O. FREQUENCY STABILITY: ±C.F. .003%

P. AVERAGE POWER: 6 WATTS

Q. CODING AND/OR MODULATION: PAM/FM/FM

ANTENNA CHARACTERISTICS

A. LOCATION:

STA. 1102	AZ. 115°	36B
STA. 920	AZ. 295°	
STA. 1102	AZ. 105°	36A
STA. 920	AZ. 285°	

WITH REFERENCE TO TRUE NORTH AFTER THE VEHICLE IS ERECTED ON THE LAUNCH PAD.

B. TYPE: Stub Fed Canted Wave Guide

C. MODEL: 55-13772-1

D. MANUFACTURER: Convair

E. FREQUENCY RANGE: 2200 – 2300 MHz

F. [ ] TUNABLE [X] FIXED TUNED

G. PREDOMINANT POLARIZATION: *(Check only one)*

[ ] VERTICAL

[ ] HORIZONTAL

[ ] CIRCULAR: SENSE: [ ] LH [ ] RH

[X] OTHER Linear, parallel to roll axis

H. MAXIMUM GAIN IN DB WITH RESPECT TO ISOTROPIC: 3 DB

I. MAIN LOBE BEAM WIDTH IN DEGREES AT 3DB POINTS: ELEVATION N/A AZIMUTH Omnidirectional

J. EFFECTIVE RADIATED POWER: 3.5 WATTS nominal

(Using 0 DB transmitting antenna gain)

K. Nulls are not greater than -11 db for 90% of radiation sphere.

L. Antenna Pattern measurements, per NRDM 80-2 have been provided.

Table 3. Centaur telemetry link

GENERAL INFORMATION	TRANSMITTER CHARACTERISTICS	ANTENNA CHARACTERISTICS
A. TEST CODE: A, B, C, D B. NUMBER OF CHANNELS: 18 CONTINUOUS: 12 COMMUTATED: 6 C. NUMBER OF SEGMENTS/CHANNEL. CHANNEL — SEGMENTS 8 — 60 9 — 60 11 — 60 12 — 60 15 — 60 18 — 60 D. STATE NON-IRIG PARTICULARS: Channel 16 is a non-standard PCM train Channel 13 contains spacecraft data.	A. LOCATION: 2nd STAGE B. TYPE FM C. MODEL: CTM- (GDC 55-01352-1) D. MANUFACTURER: Conic E. LINK FREQUENCY: 2202.5 MHz F. TYPE OF MODULATION: PAM/FM/FM G. BANDWIDTH AT 3DB: 0.15 MHz H. BANDWIDTH AT 60DB: 0.65 MHz I. IS THE ASSIGNED FREQUENCY MEASURABLE IN THE MODULATED LINK RF SPECTRUM? ☒ YES ☐ NO J. IF I ABOVE IS NO, LIST A MEASURABLE CHARACTERISTIC FREQUENCY: N/A MHz K. INDICATE THE FIXED DIFFERENCE FROM ASSIGNED FREQUENCY: N/A kHz L. MINIMUM DEVIATION: 0 kHz M. MAXIMUM DEVIATION: ±400 kHz N. FREQUENCY STABILITY: ±66.2 kHz O. FREQUENCY STABILITY: %C.F. ±0.003% P. AVERAGE POWER: 6 WATTS Q. CODING AND/OR MODULATION: FM/FM **NOTE:** Transmitting systems which require extensive periods of RF checkout time will be required to be equipped with a closed loop or non-radiating checkout device.	A. LOCATION STA. 171 AZ 150°, STA. 175 AZ 324° } 36A STA. 171 AZ 160°, STA. 175 AZ 334° } 36B WITH REFERENCE TO TRUE NORTH AFTER THE VEHICLE IS ERECTED ON THE LAUNCH PAD. B. TYPE Stub Fed Canted Wave Guide C. MODEL 55-13772-1 D. MANUFACTURER Convair E. FREQUENCY RANGE 2200-2300 MHz F. ☐ TUNABLE ☒ FIXED TUNED G. PREDOMINANT POLARIZATION: (Check only one) VERTICAL ☐ HORIZONTAL ☐ CIRCULAR: SENSE: ☐ LH ☐ RH ☒ OTHER Linear, parallel to roll axis H. MAXIMUM GAIN IN DB WITH RESPECT TO ISOTROPIC: DB I. MAIN LOBE BEAM WIDTH IN DEGREES AT 3DB POINTS ELEVATION AZIMUTH } Omnidirectional; nulls not greater than -11 db for 90% of radiation sphere. J. EFFECTIVE RADIATED POWER: 3.5 watts nominal K. Antenna pattern measurements, per NRDM 80-2 have been provided.

Table 4. Telemetry system (inertial guidance data)

R.F TRANSMISSION CHARACTERISTICS	PCM DATA	DATA TO BE TRANSMITTED AND REMARKS
A. RF FREQUENCY: 2202.5 MHz	A. IDENTIFY SERIAL BIT RATE: 800 BPS	Second stage guidance system parameters. Channel 16 (IRIG) contains serial bit data. This data is generated by the inertial guidance set and is used for trajectory and orbit determination and for guidance set performance evaluation.
B. BANDWIDTH AT 3DB POINTS: MHz	B. INDICATE SERIAL WAVE TRAIN: [X] 2 LEVEL [ ] MORE THAN 2 LEVEL IF MORE THAN 2 LEVEL: SHOW NUMBER OF LEVELS, WHAT EACH LEVEL REPRESENTS AND AMPLITUDE OF EACH LEVEL IN PERCENTAGE OF TOTAL AMPLITUDE SPREAD.	
C. BANDWIDTH AT 60DB POINTS: MHz	C. IS MODULATION DIRECTLY ON: [ ] RF CARRIER [X] SUB CARRIER	
D. DEVIATION: MHz	D. SERIAL BINARY "ONE" CAUSES THE RF CARRIER OR SUB CARRIER TO: [X] INCREASE IN FREQUENCY [ ] DECREASE IN FREQUENCY	
E. TYPE MODULATION: FM	E. SERIAL WAVE TRAIN: [ ] RETURNS TO ZERO [X] NON-RETURN TO ZERO [ ] SPLIT PHASE [ ] OTHER DESCRIBE:	
	F. WORDS PER MAJOR FRAME: 25	
	G. MINOR FRAMES PER MAJOR FRAME: NA	
	H. WORDS PER MINOR FRAME: NA	
	I. BITS PER WORD: 25	
	J. SYLLABLES PER WORD: 1	
	K. BITS PER SYLLABLE: 25	
	L. CHANNEL ASSIGNMENT: 16 IRIG *(i.e., channel 247 telemetered on major frame word X, minor frame word Y, syllable Z, etc.)*	
	M. MAJOR FRAME SYNC PATTERN: 28 "1"	
	N. MINOR FRAME SYNC PATTERN: NA	
	O. WORD SYNC PATTERN: "1" "1" "0"	
	P. GIVE SYNC PATTERN OF ANY OTHER WORD WHICH DIFFER FROM THE PATTERN IN (O): NA	
	Q. FORMAT: [ ] SHORT CYCLES [ ] PREMATURE RECYCLES NA	
	R. BINARY "ONES" AND "ZEROS" CONSTANT WIDTH: [X] YES [ ] NO	
	S. [ ] BINARY COUNT FOR 100% DATA LEVEL. NA [ ] BINARY COUNT FOR 0% DATA LEVEL. NA	
	T. SIGNIFICANT BIT COUNT OCCURS: [X] FIRST IN BIT STREAM [ ] LAST IN BIT STREAM	

Table 5. Key flight events

Event* Symbol	Event	Average Time from Launch (Sec)
	Lift-off (5.08-cm or 2-in motion)	0.0
BECO	Atlas BECO	150.0
	Atlas booster engine jettison	153.0
	Centaur insulation panel jettison	195.0
	Nose fairing jettison	232.0
VECO	Atlas SECO and VECO	248.0
	Atlas/Centaur separation	250.0
	Centaur MES	260.0
MECO	Centaur MECO	714.0
SEP	Centaur/Mariner separation	809.0
REOR	Begin Centaur reorientation	1269.0
VS	Start Centaur V 1/2 on deflection thrust	1364.0
DSPL	End V 1/2 on	1384.0
BDS	Start blowdown	1714.0
BDO	End blowdown	1964.0

*As used in the figures in this document

Table 6. Project requirements for C-band radar and S-band radio metric data

Class I	Class II	Class III
Launch to MECO + 30 sec	Launch to MECO + 30 sec	Launch to MECO + 30 sec
Any 120 sec between MECO + 5 sec (injection) and MECO + 650 sec	First continuous 120 sec between injection (MECO + 5 sec) and MECO + 650 sec	All of interval from injection to MECO + 650 sec
	Any 120 sec between MECO + 1250 sec and MECO + 4850 sec (post blowdown data)	Entire interval between MECO + 1250 sec and MECO + 4850 sec (post blowdown)
Two way acquisition of spacecraft acquisition plus one hour (S-band data)		
All data transmitted to RTCS in real time.		

Table 7. Project requirements for launch vehicle telemetry data

Links	Class I	Class II
Atlas (2215.5 MHz)	T-75 min to T + 5 min	
Centaur (2202.5 MHz)* Channels 1 - 18	T-75 min to Spacecraft Sep + 5 sec	AOS to LOS for Stations Bermuda, Antigua, Ship, Ascension, Canary Island, Tananarive
Centaur (2202.5 MHz) Channel 13 (Spacecraft Data)	L-10 min to Centaur/Spacecraft Separation	Merritt Island AOS to LOS

*Real-time transmission to Building AE until Antigua set. Near real-time to AE after Antigua set.

Table 8. Project requirements for spacecraft telemetry data

Links	Class I	Class II
Spacecraft (Engineering 33-1/3)	Start of Spacecraft countdown to L-10 min Spacecraft Separation -5 sec to DSN initial acquisition	Launch - 10 min until initial DSN acquisition (entire interval)
DSS 71 required to process AFETR/KSC spacecraft data for retransmission to SFOF and Building AO until DSN initial acquisition.		

Table 9. Flight sequence for deep space phase

No.	Flight Sequence	Time (T=0 at Liftoff, Mariner 9 S/C only, at 2223Z, 30 May 71)
1.	Pre-Maneuver	Acquisition to 1st Maneuver
2.	1st Maneuver	T +2 to +30 days
3.	Cruise	1st to 2nd Maneuver
5.	Pre-Insertion Sequence	Orbit Insertion -5 to -1 days
6.	Insertion, 1st Spacecraft	$I_1 = 0$ (2nd spacecraft only) (est. 0005Z, 14 Nov 71)
7.	Insertion, 2nd Spacecraft	$I_2 = I_1 + 10$ days
8.	First Trim, both Spacecraft	I + 1 to 2 days
9.	Science Operations	From I+1 day to I+90 days

Table 10. Spacecraft tracking requirements

Item	Time/Distance Coverage and Sampling Rate	Data Required
1.	Injection to injection + 1 hour, continuous coverage*	Hour angle Declination Two-way doppler
2.	Injection + 1 hour to injection + 4 hours, continuous coverage	Hour angle Declination Two-way doppler
3.	Injection + 4 hours to injection + 2 days, continuous coverage from DSN sites. Data received from at least 3 different sites	Two-way doppler S-band ranging
4.	Injection + 2 days to 1st maneuver - 2 days, two full passes per day limited to DSN sites only	Two-way doppler S-band ranging
5.	1st maneuver - 2 days to 1st maneuver + 12 hours continuous coverage from DSN sites	Two-way doppler S-band ranging
6.	1st maneuver + 12 hours to 1st maneuver + 5 days, two full passes per day limited to DSN sites only	Two-way doppler S-band ranging
7.	Transit cruise, one complete horizon-to-horizon pass every 4 days with no more than 3 consecutive tracks from a single station Data received from at least 3 different sites in roughly equal amounts	Two-way doppler S-band ranging

*Data sent in near-real time from selected stations to AFETR, RTCS

Table 10 (contd)

Item	Time/Distance Coverage and Sampling Rate	Data Required
8.	2nd maneuver - 2 days to 2nd maneuver + 2 day continuous coverage from DSN sites	Two-way doppler S-band ranging
9.	2nd maneuver + 1 day to 2nd maneuver + 5 days, two full passes per day limited to DSN sites only	Two-way doppler S-band ranging
10.	Insertion - 7 days to insertion + 7 days, continuous coverage from DSN sites	Two-way doppler S-band ranging
11.	Insertion + 7 days to insertion + 90 days, 6 hours per day + 1 full horizon-to-horizon pass every 4 days, with no more than 3 consecutive tracks from a single station. Also each Earth occultation event must be observed.	Two-way doppler S-band ranging
12.	Insertion-to-Insertion + 90 days, during each occultation	Two-way doppler One-way doppler from open loop receiver

Note: Computer compatible digital tapes of all data from open-loop receivers available to the experimenter at the SFOF within 6 hours of the exit occultation from DSS 14, and within 2 weeks of exit occultation from DSS 41 and DSS 62. Some form of real-time digitization accomplished at DSS 14 to alleviate data degradation caused by analog recording. TDS prediction program included capability to output data for open-loop receiver operation.

Table 11. Spacecraft tracking accuracy requirements

Parameter	Value	
1. Doppler Accuracy		
a) High Frequency Noise (1 min avg)	0.005 Hz	
b) Troposphere Calibration (Over one pass)	0.5 m	
c) Charged Particle Calibration (Over one pass)	1.0 m	
2. Range Accuracy	For Range Used as a Data Type	For Charged Particle of Doppler Calibration to 1 m Level
a) High Frequency Noise (5 min avg)	3 m	1.0 m
b) Change in Range Bias (Over one pass)	2 m	1.0 m
c) Range Bias (Over one pass)	10 m	Not applicable
3. Angle Accuracy		
a) Effective Data Noise (During first 4 hours of mission for 60 sample per sec)	0.05 deg	
4. Transmitter Frequency Stability ($\Delta f/f$ over one pass)	5×10^{-12}	

Table 11 (contd)

Parameter	Value
5. Variation in Electrical Phase Path (Over one pass)	0.4 m
6. Timing a) Universal Time with Respect to Atomic Time b) Time Synchronization with Respect to Master Clock	 2.5 msec 20 μsec
7. DSS Location	$\sigma_\lambda = 1.0$ m $\sigma_{r_s} = 0.5$ m
8. Earth Pole Location	$\sigma_x = 0.7$ m $\sigma_y = 0.7$ m

Table 12. Spacecraft telemetry data acquisition requirements

CHANNEL			DATA RATE	RECORDING INTERVAL (*Time, position or flight phase*)	REAL TIME REQUIREMENT		PURPOSE AND REMARKS
NO.	FREQUENCY*	NO. OF SEGMENTS			DISPLAY	COMPUTER	
Item 1	Spacecraft telemetry via spacecraft link		All channels and rates as described in Table 9	To support primary mission objectives, periodic support is required from DSS 71 for pre-launch testing	Data required in real time. See remarks.		1. a. Spacecraft - DSN compatibility. b. Check spacecraft frequencies before launch c. Data to be delivered in real time to the SFOF & Bldg. AO, CKAFS.
Item 2	Spacecraft telemetry via spacecraft link		Same	Class I. From start of spacecraft countdown to launch -10 min Class II. Launch -10 min to DSS 71 LOS	Data required in real time. See remarks.		2.a. Spacecraft performance monitoring. b. Check spacecraft frequencies during launch countdown. c. DSS 71 process data for transmission to SFOF* & Bldg. AO during countdown from launch to DSN initial acquisition. DSS 71 process data from near-Earth ground station sources for transmission to SFOF and Bldg. AO.

*See Table 9 for frequencies
All real-time telemetry from spacecraft is input in real time to both the IBM 360/75 and MTC.

Table 12 (contd)

CHANNEL			DATA RATE	RECORDING INTERVAL (*Time, position or flight phase*)	REAL TIME REQUIREMENT		PURPOSE AND REMARKS
NO.	FREQUENCY	NO. OF SEGMENTS			DISPLAY	COMPUTER	
Item 3 No IRIG conformance (S/C telemetry via S-band)			33-1/3, 8-1/3 bps Eng	To support Primary Mission Objectives. Continuous coverage from DSN acquisiton to acquisition plus 2 days.	Transmission to SFOF*		S/C performance monitoring, engineering evaluation, and failure detection.
Item 4 No IRIG conformance (S/C telemetry via S-band)			33-1/3, 8-1/3 bps Eng	To support Primary Mission Objectives. Continuous coverage from 1st maneuver minus 2 days to plus 12 hours.	Transmission to SFOF*		S/C performance monitoring
Item 5 No IRIG conformance (S/C telemetry via S-band)			33-1/3, 8-1/3 bps Eng	To support Primary Mission Objectives. During transit cruise periods, coverage 50% of each 24 h with no gap greater than 7 hours.	Transmission to SFOF*		S/C performance monitoring
Item 6 No IRIG conformance (S/C telemetry via S-band)			33-1/3, 8-1/3 bps Eng	To support Primary Mission Objectives. Continuous coverage from 2nd maneuver minus 2 days to plus 2 days.	Transmission to SFOF*		S/C performance monitoring
Item 7 No IRIG conformance (S/C telemetry via S-band)			33-1/3, 8-1/3 bps Eng Channel	To support Primary Mission Objectives. Continuous coverage from orbit insertion minus 7 days to plus 90 days.	Transmission to SFOF*		S/C performance monitoring
Item 8 No IRIG conformance (S/C telemetry via S-band)			50 bps	To support Primary Mission Objectives. Continuous coverage from orbit insertion minus 5 days** to plus 90 days.	Transmission to SFOF*		Scientific data

Note: Provide capability during transit cruise periods to call up 50 bps low rate science data on an emergency mode basis.

* All real-time telemetry from spacecraft is input in real time to both the IBM 360/75 and the MTC.

** Pre-insertion sequence of 2nd spacecraft will begin at 5 days before insertion <u>or</u> when both spacecraft are within the 64-meter antenna beam, whichever is later.

Table 12 (contd)

CHANNEL			DATA RATE	RECORDING INTERVAL (*Time, position or flight phase*)	REAL TIME REQUIREMENT		PURPOSE AND REMARKS
NO.	FREQUENCY	NO. OF SEGMENTS			DISPLAY	COMPUTER	
Item 9 No IRIG conformance (S/C telemetry via S-band)			16, 8, 4 kbps (high rate)	To support Primary Mission Objectives. Daily coverage from orbit insertion minus 5 days ** to plus 90 days during Goldstone visibility.	HSD transmission of data from both S/C in real time, to SFOF ***		Scientific data
Item 10 No IRIG conformance (S/C telemetry via S-band)			2, 1, kbps (high rate)	As required to backup or extend Goldstone high-rate data reception. Continuous coverage from orbit insertion minus 5 days ** to plus 90 days.	HSD transmission of data from either S/C in real time, to SFOF ***		Scientific data

Note

Spacecraft orbit insertions are separated by 10 days.

**Pre-insertion sequence of 2nd spacecraft will begin at 5 days before insertion <u>or</u> when both spacecraft are within the 64-meter antenna beam, whichever is later.

***All real-time telemetry from spacecraft is input in real time to both the IBM 360/75 and the MTC.

Table 13. Spacecraft telemetry data acquisition accuracy requirements

Channel	Bit Rate	Max Acceptable Bit Error Rate	Duration (Days) at 90% Probability
High Rate Coded Science Playback	16 kbps*	5×10^{-3}	I -20 to I +30
	8 kbps*	5×10^{-3}	I -20 to I +90
	4 kbps*	5×10^{-3}	I -20 to I +90
	2 kbps	5×10^{-3}	I -20 to I +30
	1 kbps	5×10^{-3}	I -20 to I +90
High Rate Coded Science Real Time**	8 kbps*	1×10^{-4}	I to I +30
	8 kbps*	5×10^{-3}	I -20 to I +90
	16 kbps*	5×10^{-3}	I -20 to I +30
Low Rate Uncoded Science	50 bps	5×10^{-3}	I -20 to I +90
Engineering	8-1/3 bps	1×10^{-2}	L to I +90
	8-1/3 bps***	1×10^{-4}	I -20 to I +30
	33-1/3 bps	5×10^{-3}	L to DSN Acquisition

L = Launch

I = Insertion

*Requirement applies to 64-meter antenna

**IRIS Data only

***CC&S Memory Dump Mode

Table 14. Project requirements for ground communications

TYPE OF SERVICE	LOCATION OF OPERATING TERMINALS	BANDWIDTH	CHANNELS	DATA RATES	PURPOSE
1. Voice Transmission	Tracking Stations, DSN Facilities and Stations supporting Project to SFOF and SAF	3 kHz	1-FDX Each location		Voice coordination compatibility test and mission.
2. Engineering Telemetry					
a) High Speed Data	Tracking Stations and DSN Facilities supporting Project to SFOF	3 kHz	1-HSD (FDX)(4.8 kbps)	8 1/3, 33 1/3 bps	Compatibility tests and mission operations.
b) TTY (Backup)	Tracking Stations and DSN Facilities supporting Project to SFOF		2-TTY (FDX) 100 wpm	50 bps (max linerate)	Compatibility tests and mission operations.
3. High Rate Telemetry from Overseas (HSD)	DSN stations supporting high rate data channel overseas to SFOF	3 kHz	1 ea DSS	2, 1 kbps	Test and mission operations support.
4. Low Rate Science Telemetry (HSD)	DSN stations supporting Project to SFOF	3 kHz	Multiplexed with Item 2	50 bps	Test and mission operations support.
5. High Rate Telemetry (Wideband)	DSS-14 to SFOF	1 MHz	1-FDX (50 kbps)	16, 8, 4, 2, 1 kbps	Test and mission operations support.
6. Command Data (HSD)	SFOF to DSN stations supporting Project and SAF	3 kHz	Multiplexed with Item 2	1 bps	Compatibility test and mission operations support.

Table 14 (contd)

TYPE OF SERVICE	LOCATION OF OPERATING TERMINALS	BANDWIDTH	CHANNELS	DATA RATES	PURPOSE
7. Tracking Data (TTY)	Tracking stations supporting Project to SFOF. (Backfeed from GSFC to RTCS/ETR test and near-earth phases only)		1-FDX (100 wpm)	50 bps (max line rate)	Test and mission operations support.
8. High Rate Tracking (HSD)	DSS 14 to SFOF	3 kHz	Multiplexed with Item 2	1.2 kbps	Support occultation experiment.

Table 15. Ground communications simulation support (all phases)

TYPE OF SERVICE	LOCATION OF OPERATING TERMINALS	BANDWIDTH	CHANNELS	DATA RATES	PURPOSE
1. Simulation Telemetry Data (Long Loop)			Items 1 a, b, c and d below multiplexed and accommodated by single HSD circuit		Training of mission operations personnel
a) Engineering HSD Telemetry	SFOF to DSN, MSFN, and ETR (through DSS71 interface) stations supporting Project.	3 KHz	1-FDX (4.8 kbps) ea DSN/MSFN/ETR station.	8 1/3 and 33-1/3 bps (1 spacecraft to DSS71, 2 spacecraft other DSSs)	Transmit simulation data
b) Science Low-Rate HSD Telemetry	SFOF to DSN stations supporting Project (N/A at DSS 71)	3 kHz	Same as Item a.	50 bps (2 spacecraft)	Transmit simulation data
c) Science High-Rate HSD Telemetry	SFOF to DSN station supporting Project (N/A at DSS 71)	3 kHz	Same as Item a.	2, 1, kbps (1 spacecraft)	Transmit simulation data
d) RF Control HSD	SFOF to DSN stations supporting Project (N/A at DSS 71)	3 kHz	1 - FDX	8 bps	Simulation coordination and control
e) Science High Rate	SFOF to DSS 14, CTA 21	48 kHz	1 - FDX (50 kbps)	16, 8, 4 kbps (2 spacecraft)	Transmit simulation data
2. Simulation Telemetry Data (Short Loop)					
a) HSD Telemetry	SFOF Simulation Center to SFOF Communication Terminal	3 kHz	3-FDX (4.8 kbps)	8 1/3 - 33 1/3, 50 bps 2, 1 kbps (2 spacecraft)	Transmit simulation data

Table 15 (contd)

TYPE OF SERVICE	LOCATION OF OPERATING TERMINALS	BANDWIDTH	CHANNELS	DATA RATES	PURPOSE
b) Wideband Telemetry	SFOF Simulation Center to SFOF	48 kHz	1-SPX (50 kbps)	16, 8, 4 bps (2 spacecraft)	Transmit simulation data
3. Simulation Tracking TTY Data	SFOF Simulation Center to SFOF		1-FDX (100 wpm each DSS and RTCS at AFETR)		Transmit simulation tracking data.(SFOF internal only)
4.a Deleted					
b) Voice	SFOF to CTA 21, SAF, and DSS supporting Project		1-FDX Each location		Test coordination

Table 16. Mission Support Area requirements

Function	Area, m^2	BOD
Operations		
Spacecraft	233.0	6/1/70
Science Data Handling	233.0	11/1/70
Navigation	158.0	11/1/70
Science Recommendation	196.0	1/1/71
Data Processing	168.0	11/1/70
Cruise Control	28.0	1/1/71
Conference Room	37.2	1/1/71
Project Manager	18.6	1/1/71
ACMO Command Team	112.0	11/1/70
Command	18.6	11/1/70
Information Release	28.0	1/1/71
Data Systems*		
TV-1**	466.0	11/1/69
Mission Test Computer	186.0	11/1/69
Univac 1108	931.0	11/1/70
Simulation Control***	33.5	8/1/70

*Power and environment provisions suitable for operation support
**Existing Surveyor facilities are adequate
***Located contiguous to DSN SIMCEN

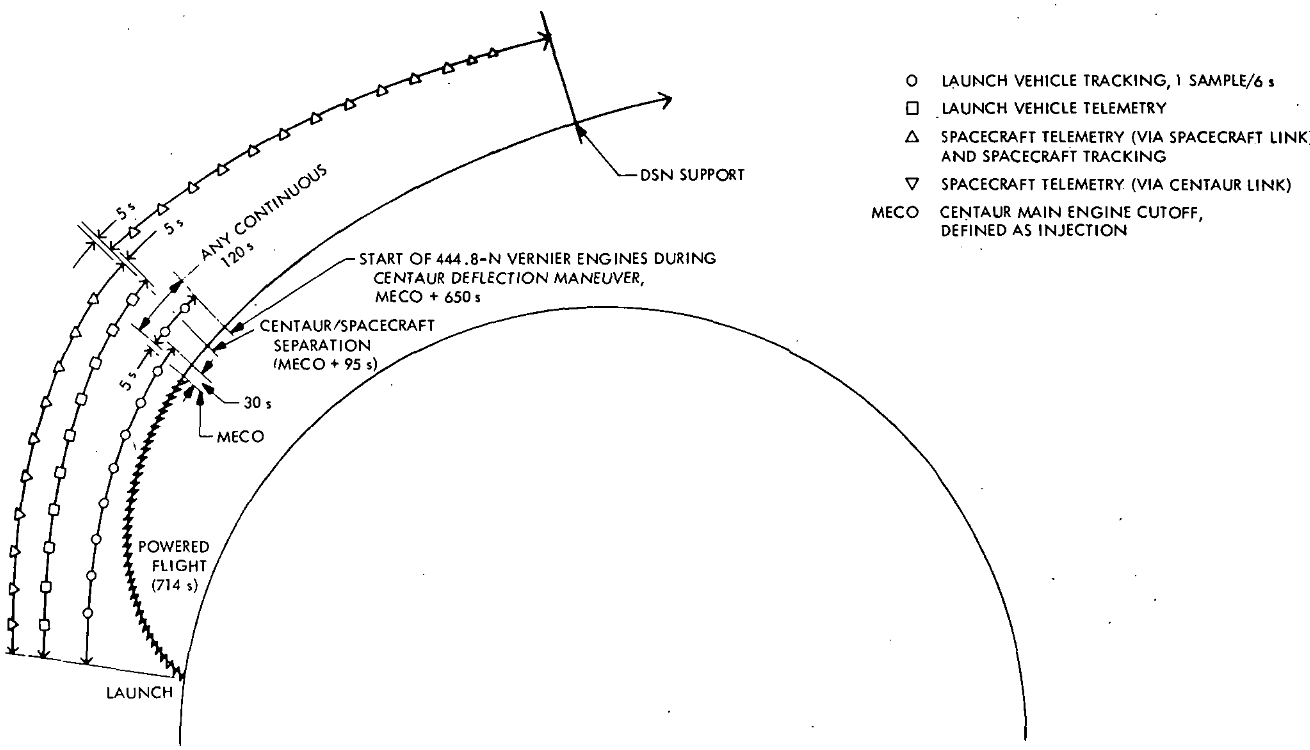


Fig. 8. Near-Earth Class I TDA requirements

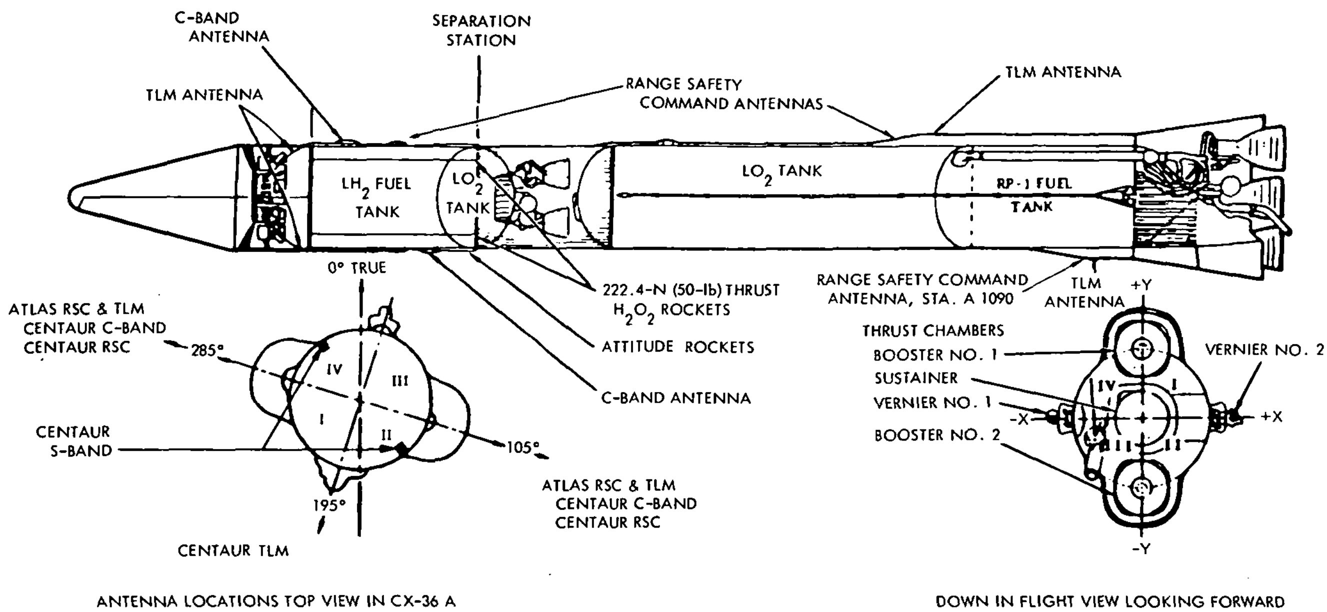


Fig. 9. Atlas/Centaur launch vehicle for Mariner Mars 1971

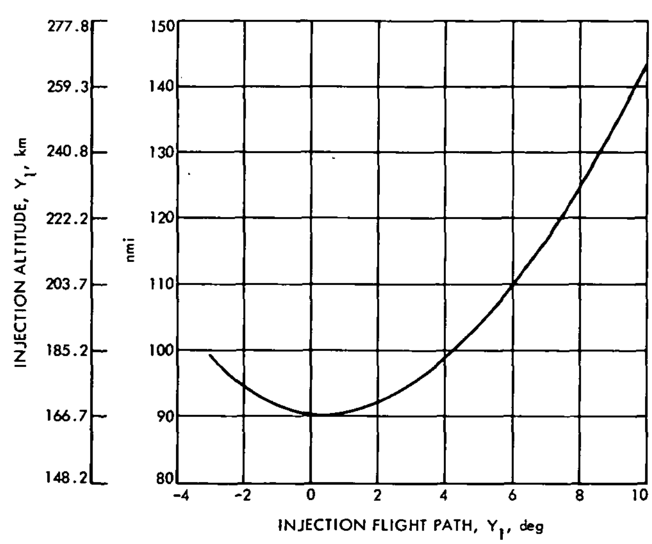
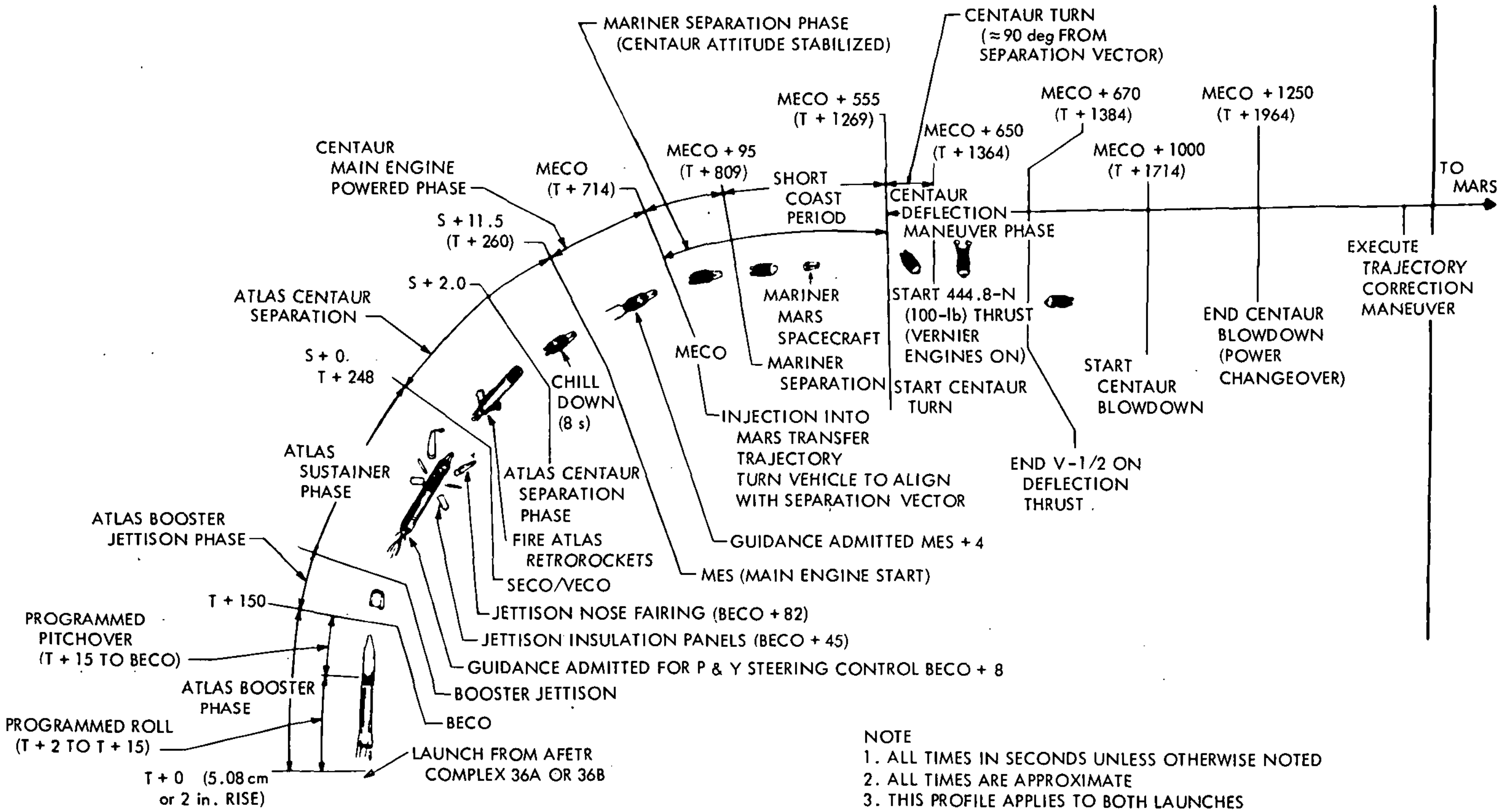


Fig. 10. Injection altitude vs injection flight path angle



NOTE
1. ALL TIMES IN SECONDS UNLESS OTHERWISE NOTED
2. ALL TIMES ARE APPROXIMATE
3. THIS PROFILE APPLIES TO BOTH LAUNCHES

Fig. 11. Mariner Mars 1971 trajectory profile

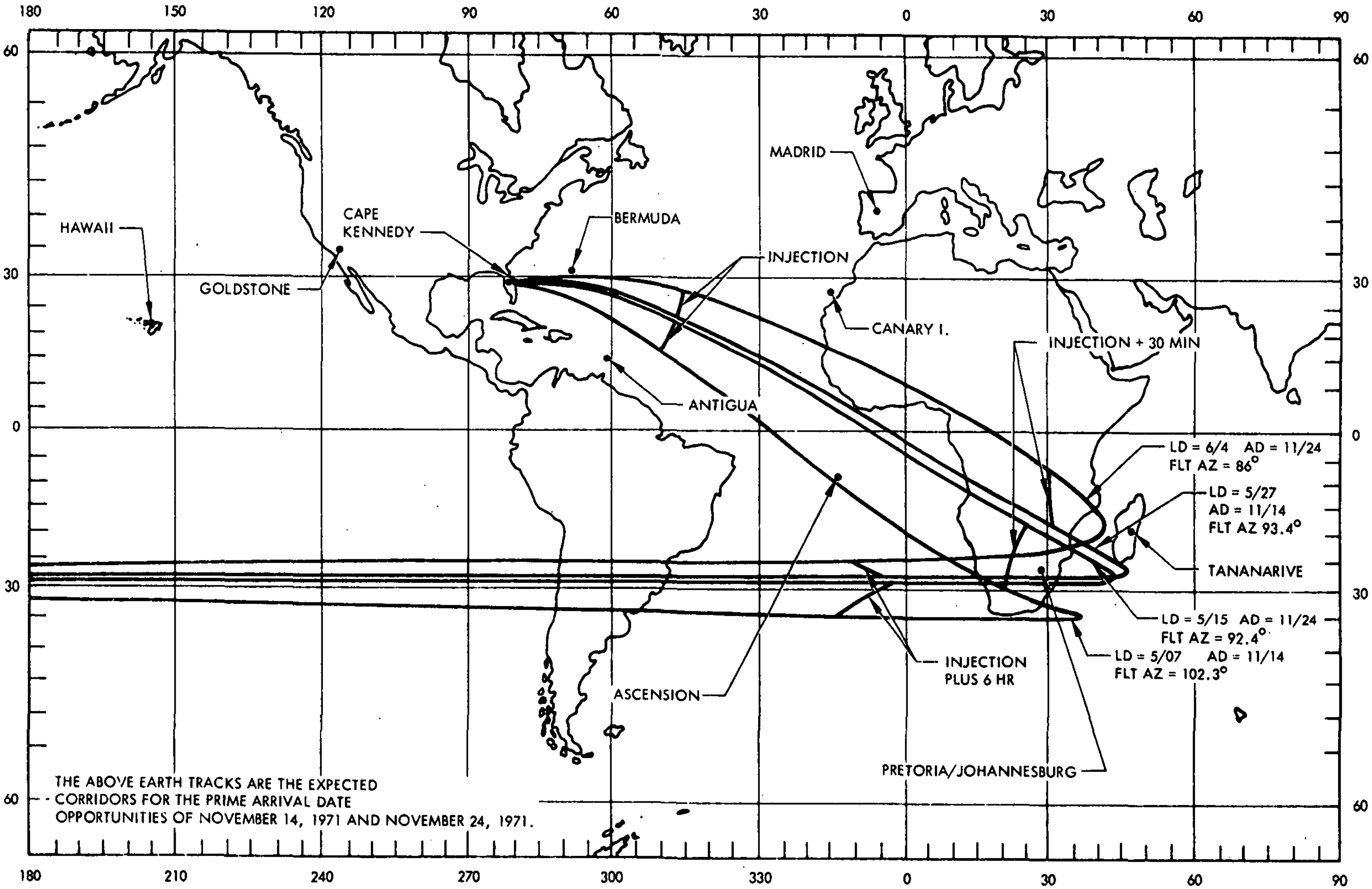


Fig. 12. Earth tracks of expected launch azimuth corridors

A. Planning Activities

1. Support of Mission Design. The flight Project requirements on the TDS which are summarized in the previous section resulted ultimately in a TDS Operations Plan. Although the plan was for the anticipated support of the Project in response to the requirements, the formulation of the plan was a closely coordinated effort between mission operations personnel and TDS personnel. Mission Operations was defined as an activity distinct from the management element of MOS and included (1) a Data System, (2) a Software System, and (3) an Operations System. Since the Data System was defined to include all Earth-based equipment provided by all systems of the Project for the receipt, handling, transmission, processing, and display of spacecraft data and related data during Mission Operations, the TDS constituted the major portion of the Data System, excepting only some relatively small amounts of mission-dependent equipment supplied by the flight project. In the near-Earth phase, facilities of the AFETR and MSFN were included. The Software System included all computer programs and associated documentation provided by either the MOS or TDS for the accomplishment of Mission Operations. The Operations System was defined to include the personnel, plans, and procedures provided by the MOS and TDS required for the execution of the Mission Operations. The responsibilities and management arrangements for these three areas are shown in Fig. 13. The design activities for the DSN were conducted by the DSN Interface Team.

Mission Operations System and TDS activities in preparation for operations can be divided into phases as illustrated in Fig. 14. Figure 15 illustrates the division of prime responsibility between the MOS and TDS for the phases of preparation.

The Mission Operations design process which the DSN supported through these three teams is shown in Fig. 16. The Mission Operations Design Team formulated system-level functional requirements. From these requirements, as well as from the Project requirements stated in the SIRD, the DSN formulated the DSN configuration and plan and the near-Earth coordinator formulated the near-Earth configuration and plan. These plans, taken together, constituted the TDS Operations Plan.

2. Support plans. TDS plans were set forth in the NASA Support Plan (NSP), DSN Operations Plan for MM '71, DSN Test Plan for MM '71, and the Near-Earth Phase Operations Plan for MM '71. The plan included interface descriptions between the deep space and near-Earth phases of the TDS, interfaces with the spacecraft and MOS, and a Compatibility Test Plan for testing the interface design. Support by the MSFN was covered separately by an MSFN Operations Plan for MM '71.

The NSP stated the general capabilities to be supplied by the TDS in response to the Project requirements stated in the SIRD. All the major and significant project requirements were met by operational capabilities of the TDS, or in some cases, by experimental DSN equipment such as planetary ranging and X-band moon-bounce time synchronization.

DSN/MM '71 Systems Configuration for near-Earth and deep space phases are presented in Subsections B and C below for prelaunch through first midcourse maneuver. Near-Earth phase configurations are presented under five systems: Telemetry, Tracking, Simulation, Command, and Operations Control. Deep-space phase configurations are presented under six basic systems: Telemetry, Tracking, Command, Simulation, Monitoring, and Operations Control. DSN/MM '71 systems configurations described in this volume were used through the first midcourse maneuver, even though the Mariner 8 spacecraft was lost at launch and dual spacecraft requirements were not needed. DSN/MM '71 systems configurations were changed after the first midcourse maneuver of the Mariner 9 spacecraft. These changes will be presented in Volume II of this Technical Memorandum.

B. Near-Earth Phase Configuration

Tables 17 and 18 indicate near-Earth TDS resources used in support of Mariner 71; Tables 19 and 20 indicate requirements to be supported by these resources.

1. Telemetry System. The Telemetry System of the near-Earth phase TDS was configured to provide telemetry data transmitted from the launch vehicle and spacecraft systems. Figure 17 illustrates the near-Earth phase TDS Telemetry System for the recovery and retransmission of launch vehicle and spacecraft data.

Telemetry functions were to (1) receive, record, and process Atlas and Centaur telemetry data and retransmit selected channels of Centaur telemetry data to the launch vehicle data analysis center in Building AE, Kennedy Space Center (KSC) (Atlas telemetry data was acquired and displayed in the Building AE telemetry laboratory) and (2) receive, record, and process engineering telemetry via Centaur telemetry channel 13 until separation, and via the spacecraft link after separation and retransmit to the SFOF, JPL, Pasadena.

The salient features of the near-Earth telemetry configuration were:

(1) The Antigua and Ascension stations were used to provide telemetry support for the MM '71 Project requirements.

(2) The telemetry station at Cape Kennedy was used to comply with range safety requirements.

(3) The Antigua station transmitted required Centaur performance and guidance data via the Centaur link (22^2.5 MHz) in real time to the Building AE telemetry laboratory, using the subcable. Channel 17 was excepted from this transmission and recorded in real time for playback to Building AE at half speed, in near-real-time.

(4) The Ascension AFETR station discriminated the guidance data from channel 16 and transmitted the 800-bits/s pulse-code modulation (PCM), non-return-to-zero (NRZ) data to Building AE using 202 modems. A NASCOM circuit was used between Ascension and the Cape.

(5) Selected Centaur performance data channels were transmitted to Building AE using the AFETR satellite communications circuit.

(6) In-flight vehicle events were reported by the Antigua, Ascension, and Cape Kennedy telemetry stations by forwarding observations of data displayed at the stations.

(7) The Antigua station provided DSS 71 at Cape Kennedy with spacecraft telemetry data recovered from the Centaur link and the spacecraft link. Each telemetry data source was transmitted in real time using 202D data modem circuits. A JPL-provided phase-shift keyed (PSK) demodulator was used in the recovery of the data received from the spacecraft link.

(8) The Ascension Station had the capability of transmitting spacecraft data after separation to be used only in the event that the MSFN system at Ascension failed. Should this have occurred, the station would have demodulated the 24-kHz subcarrier and retransmitted the data to DSS 71 at 33-1/3 bits/s on a 3-kHz data circuit.

(9) The KSC telemetry system comprised support by the Central Instrumentation Facility (CIF) on Merritt Island and the telemetry acquisition facilities of the Unmanned Launch Operations (ULO) directorate. These latter facilities include the Satellite Tracking Station (STS) and Building AE. Figure 18 shows the routing of these data.

(10) Channel 13 of the Centaur telemetry link was discriminated at Building AE and the spacecraft 33-1/3-bits/s PCM data were transmitted to Building AE and DSS 71 using a 202D modem circuit. DSS 71 processed the data for transmission to the SFOF. The sources of these data were the CIF and data received from Antigua via the subcable.

(11) The JPL Cape Kennedy Spacecraft Monitoring Station (DSS 71), in addition to being used for spacecraft checkout and compatibility testing, was the interface point between the DSN and the AFETR/KSC-provided spacecraft telemetry.

(12) Spacecraft data acquired by the AFETR and KSC supporting facilities were transmitted on 202-D data modem circuits to DSS 71, where the 33-1/3-bits/s data were processed for transmission on 4800-bits/s lines to the SFOF in the same fashion as other DSN stations.

(13) The received data were transmitted through a signal coordinator for selection by an automatic selector unit (ASU) before being entered into the DSN Multiple-Mission Telemetry (MMT) System. Figure 19 shows this system in simplified form.

2. Tracking System. The Tracking System of the near-Earth phase TDS was configured to provide tracking data acquired from both the launch vehicle and the spacecraft. Figure 20 illustrates the near-Earth phase TDS Tracking System used in acquiring these data. Tracking System functions were as follows:

(1) Launch vehicle: Acquire, track, and transmit Centaur position data for time azimuth, elevation, and range (TAER) to the AFETR Real-Time Computer System (RTCS).

(2) Spacecraft: Acquire, track, and transmit Mariner position data for angles and doppler to the AFETR RTCS and the JPL SFOF.

(3) RTCS: Provide acquisition data to the support stations and compute orbital elements for the Centaur and Mariner trajectories.

Figure 21 shows the AFETR Tracking Data System. The primary radars to be used for launch vehicle tracking were the Merritt Island TPQ 18 (19.18), Antigua FPQ 6 (91.18), and the Ascension Island TPQ 18 (12.18). The others indicated were used for range safety and weather balloon tracking.

A target acquisition bus was used to transmit acquisition data generated by the RTCS to all downrange stations on the subcable. Ascension received an Inter-Range Vector and converted it to predicted real-time target position data in local geographical reference.

The RTCS, using Centaur tracking data provided by the AFETR and MSFN C-band radars, supplied acquisition data in the following forms: (1) IRVs, (2) 480-pulses/s real-time acquisition bus, (3) DSIF predicts, and (4) Real-time acquisition data via the Launch Trajectory Data System (LTDS) to Bermuda and the Apollo Instrumentation Ship (AIS) Vanguard.

3. Simulation System. The Simulation System of the near-Earth phase used to the maximum extent possible the intricate Simulation Center at the SFOF, in particular, for simulation of spacecraft telemetry data. Simulation System telemetry functions were as follows:

(1) Provide communications configuration for transmission of simulation data from the SFOF SIMCEN to the near-Earth phase sites.

(2) Provide software and equipment capable of handling simulation data transmitted from the SFOF.

(3) Provide capability to play back tape recordings of simulated launch vehicle data through planned communications configuration from each site to Building AO data analysis area.

The AFETR received simulated spacecraft telemetry data transmitted from DSS 71 to each participating site on 202D data modem circuits.

Binary data were obtained from the Simulation Converter Assembly (SCA) at DSS 71. This low-rate single output drove modem transmitters for data transmission to supporting stations. At the remote sites, the received low-rate serial data stream could be modulated, passed through the local RF loop, demodulated, and retransmitted to DSS 71 for reformatting into the HSD and transmission back to the SFOF.

A lower level of simulation could also be accomplished by using a binary data generator at DSS 71 to supply supporting stations. Likewise, simulation could be accomplished at the station level. Tape recordings played back from participating stations were used to simulate launch vehicle telemetry data.

Figure 22 illustrates the MSFN configuration used to support simulation data transmission for testing and training. Binary data that simulates spacecraft operation were generated at the SFOF and formatted for transmission to GSFC. Here the data were sent to MSFN stations supporting the mission. A 642B computer at each MSFN station received and decoded engineering mode data. Output of the computer updated a stored program in a PCM data simulator that fed local subsystems. This updated serial data could be modulated, demodulated, reformatted, and retransmitted to the SFOF. Launch vehicle telemetry was simulated by playing back tape recordings from the participating sites.

Figure 23 illustrates the MSFN plan for tracking data simulation. The near-Earth phase trajectory analyst coordinated with the navigation group in the selection of the nominal trajectory for tracking data simulation testing. The GSFC/MSFN Data Operations Branch generated simulated tracking data for AIS Vanguard, Tananarive, and Ascension. The MSFN verified data formats, conducted short-loop tests, and forwarded simulated tracking data to applicable MSFN stations that in turn played back the data during long-loop tests.

4. Command System. The Command System of the near-Earth phase TDS was configured to transfer command data to the spacecraft. In the near-Earth phase TDS, the only site configured for this capability was the MSFN Station at Ascension Island.

Command functions were to provide timing for the Read-Write-Verify (RWV) command system and to provide voice and data communications for support of the RWV command system. The command system used at Ascension Island was the RWV equipment supplied by JPL and used on the Mariner Mars 1969 Project.

5. Operations Control System. The TDS near-Earth phase Operations Control System provided information for operational control and coordination of various elements of the TDS during the near-Earth phase operations.

The Operations Control System had two functional structures: an operational structure for test and operations and a nonoperational structure for planning and review.

a. Operational structure. The operational structure shown in Fig. 24 was designed to provide real-time status and coordination required for operational control of the TDS during the near-Earth phase of mission operations. Status was passed between the JPL/ETR Mission Operations Center and the DSN, MSFN, and AFETR, as appropriate. This reporting of status included, but was not limited to, items from the SOE.

Coordination was achieved between the MSFN Operations Control (MSFN OC), the AFETR Superintendent of Range Operations (SRO) and the DSN Operations Chief (DSN OC). In addition, coordination of computed data operations was effected directly between the JPL Data Coordinator at the RTCS and the MM '71 Navigation Team.

b. Nonoperational structure. The nonoperational structure shown in Fig. 25 provided the required design, planning, coordination, analysis, status, scheduling, and documentation for pre- and post-launch operations among all elements of the TDS.

C. Deep Space Phase Configuration

The DSN Systems configuration described herein was used, from prelaunch through first trajectory correction maneuver. Revisions of the DSN Systems configuration to accommodate for the loss of Mariner 8 spacecraft have been made for the period from orbit insertion through the end of the mission and will be documented in Volume II of this Technical Memorandum.

The DSN Operations Plan included the configuration of each of the six DSN Systems planned to support MM '71. These DSN Systems are as follows:

(1) DSN/MM '71 Telemetry System (26-m-diameter antenna Deep Space Stations (DSS) and 64-m-diameter antenna station (DSS 14).

(2) DSN/MM '71 Tracking System (26-m-diameter antenna stations, DSS 14, and engineering alternate).

(3) DSN/MM '71 Command System (26-m-diameter antenna stations and DSS 14).

(4) DSN/MM '71 Simulation System (all stations).

(5) DSN/MM '71 Monitor System (all stations).

(6) DSN/MM '71 Operations Control System (all stations).

Block diagrams are used here to graphically illustrate the planned functions and data flow for each DSN System. The diagrams generally define

interfaces among subsystems of each of the three DSN facilities, between pairs of facilities, between pairs of DSN systems, and with the Project.

Each of the diagrams in this Subsection is divided into the three DSN facilities (as positioned from left to right): DSIF, GCF, and SFOF. Each facility is shown as a group of component subsystems connected with data flow paths. Footnotes in the accompanying tables provide the following details:

(1) Numbered footnotes describe the contents of data flow paths, for example, (1), (2), etc.

(2) Upper case alphabetic footnotes describe equipment/subsystem capabilities, for example, (A), (B), etc.

(3) Lower case alphabetic footnotes describe software capabilities, for example, (a), (b), etc.

(4) Roman numerals define interfaces with the diagrams of other DSN Systems. For example: In Figs. 26 and 27, (II) TO MONITOR SYSTEM interfaces the 920 of the Telemetry System with the Monitor System computer (II) (Fig. 34).

1. DSN/MM '71 Telemetry System. The DSN/MM '71 Telemetry System provides acquisition, distribution, display, and processing of MM '71 telemetry data, which is the engineering and science information received from the MM '71 flight spacecraft.

The MM '71 spacecraft signal is an RF carrier, phase modulated by one or more subcarriers. The subcarriers are phase-shift keyed with the digital telemetry data. The DSN/MM '71 Telemetry System receives the carrier, separates and demodulates the subcarrier(s), and detects the bit stream.

a. Modes of operation. The DSN Telemetry System is capable of four modes of operation, either multiple modes simultaneously at one station, or several stations in different modes simultaneously. The modes of operation are as follows:

(1) Decommutate and display selected spacecraft engineering telemetry data at the DSS.

(2) Format received telemetry data at the DSS for real-time transmission via high speed or wideband (DSS 14 only) communications after detection and bit sync acquisition. Decommutate, display, and provide further processing at the SFOF.

(3) Select or edit data for TTY transmission to the SFOF after detection and bit sync acquisition and decommutation at the DSS.

(4) Record only at the DSS, with or without bit detection.

Modes (2) and (3) above include both operation on real-time data and playback of recorded data. The MM '71 Project specifies telemetry data modes, formats, bit rates, and expected signal levels during each phase of the mission. Resultant configuration changes are made through the DSN Operations Control System.

b. DSN/MM '71 Telemetry System, 26-m-diameter antenna subnet operation. As shown in Table 21 and Fig. 26, S-band carrier downlink(s) from either or both spacecraft are received via the antenna mechanical subsystem at the DSS by the receiver/exciter subsystem. The received subcarriers are demodulated in the Subcarrier Demodulator Assemblies (SDAs). Data stream outputs from the SDAs are then fed into two Telemetry and Command Processors (TCPs) after the following routing and processing:

(1) Coded science: the coded science data stream is fed through the Symbol Synchronization Assembly (SSA) and Block Decoder Assembly (BDA) before TCP formats for GCF.

(2) Uncoded science: the uncoded science data stream is fed through the SSA before HSD formatting.

(3) Uncoded engineering: this data stream is fed directly to the TCP.

The data streams are processed, time tagged, and formatted in the TCP for output to the SFOF through the Block Multiplexer (BMXR) and HSDL of the GCF. Teletype data are also output from the TCP for backup. Digital ODR recordings are made of all telemetry data.

High-speed data to the SFOF include engineering data from both spacecraft, science from both spacecraft (or from one spacecraft plus nonscience from the other spacecraft), and DSS Telemetry System partial status. The same information is available on replay of the ODR. Backup TTY to the SFOF includes decommutated engineering and selected 50-bits/s science data from both spacecraft. High-speed data to the SFOF are input to the 360/75 and Project MTC.

The DSN/MM '71 Telemetry System displays at the SFOF User Terminal and Display Subsystem (US&D SS) include both volatile visual displays and hard copy output. The format and content are selectable for each data stream. The UT&D SS in the SFOF also includes plans for demonstration of display of video images from the spacecraft TV cameras; digital video image data from the stations are received via HSDL in standard DSN formats.

c. DSN/MM '71 Telemetry System, DSS 14 operation. As shown in Table 22 and Fig. 27, operation of the DSN/MM '71 Telemetry System is generally the same for the 64-m-diameter antenna station, DSS 14, as for the 26-m-diameter-antenna subnet, except for the addition of the processed, time-tagged, and formatted wideband (WB) data from two of the three TCPs at the DSIF. These WB data to the SFOF include two high-rate telemetry streams at 16.2 kilobits/s each, maximum.

2. DSN/MM '71 Tracking System. The DSN/MM '71 Tracking System provides validated precision radio metric data to the MM '71 Project

users by performing data acquisition, handling, editing, calibration, display, distribution, validation, and prediction. DSN tracking data are defined as range, angle, and doppler data generated by the DSIF, and associated data such as lock status, time, frequency, data condition, and calibration information.

a. Modes of operation. The DSN/MM '71 Tracking System provides five modes of operation. Simultaneous operation in more than one mode is possible, either with multiple modes at a single DSS, or with the SFOF operating in different modes with different DSS. These modes of operation are as follows:

(1) Acquire and follow each MM '71 spacecraft transponder in both frequency and angles in two-way, three-way, or one-way doppler tracking. Generate, format, display, and record the tracking data at the DSS. Collect calibration information for immediate processing at the DSS for transmission to the SFOF.

(2) Format the MM '71 data collected in mode (1) above for real-time transmission to the SFOF.

(3) Send a subset of the data formatted in mode (2) above to the SFOF.

(4) At the SFOF, edit, validate, display, and store data in a MM '71 tracking System Data Record (SDR). Process calibration information for storage in the MM '71 tracking SDR.

(5) Play back, in non-real-time, part or all of the MM '71 tracking data recorded at the DSS. Transmit the data to the SFOF, where the data will be processed as in mode (4) above.

b. DSN/MM '71 Tracking System, 26-m-diameter antenna subnet operation. As shown in Table 23 and Fig. 28, S-band downlink data from either of the two MM '71 spacecraft is received through the 26-m-diameter-antenna subnet by the receiver/exciter subsystem. Doppler and ranging data are extracted and passed to the Tracking Data Handling Subsystem (TDH), together with time and receiver/exciter frequency. The TDH formats metric data for TTY. The data are then transmitted to the 360/75s (CPS) in the SFOF. The metric data are processed in the 360/75s and sent to the UT&D SS and the 1108s. The processed metric data, which is routed to hard copy and volatile display devices of the UT&D SS, is used to validate the performance of the tracking system. The metric data is received from the 360/75s by the 1108 computers of the Scientific Computer Facility (SCF) for orbit determination and other navigation processing.

Trajectories are generated in the SCF 1108 and then flow to either of the 360/75s, where predicts are generated. Predicts are sent prepass to the appropriate stations by HSD, or by backup 100-words/min TTY paper tape. The predicts are also used to compare with the received metric data to generate pseudoresiduals. At the DSS, processed predicts are used for antenna pointing and receiver/exciter tuning. Occultation output signals from the open-loop receivers are recorded, analog recorded, and sent to the SFOF via airmail.

c. DSN/MM '71 Tracking System, DSS 14. As shown by Table 24 and Fig. 29, S-band downlinks from either or both of two MM '71 spacecraft are received through the 64-m-diameter-antenna subsystem by the receiver/exciter subsystem. Doppler and ranging data are extracted and fed to the TDH together with time and receiver/exciter frequency. A switchable doppler feature is incorporated between the receiver/exciter and the TDH to allow rapid selection of doppler data from either of two simultaneous links.

Operation of the remainder of the Tracking System is the same for DSS 14 as for the 26-m-diameter antenna subnet except for occultation output signals from the DSS 14 open-loop receivers, which are digitized, recorded digitally, and sent to the SFOF via manual transportation.

d. DSN/MM '71 Tracking System, DSS 14 engineering alternate. As shown in Table 25 and Fig. 30, S-band downlink from either, or both, of two MM '71 spacecraft is received through the 64-m-diameter-antenna subsystem by the receiver/exciter subsystem. Doppler and ranging data are extracted and fed to the DSIF Tracking Subsystem (DTS) together with time and receiver/exciter frequency. The following functions are performed in the DTS: tracking data formatting, doppler counting, planetary ranging, error detection, predict generation, antenna pointing, and time tags. Digital magnetic tape recordings are made for the ODR of all metric data output from the DTS for both spacecraft.

HSD formatted metric data are transmitted from the DTS via HSD to the 360/75s (CPS) in the SFOF. Metric data are processed in the 360/75s and sent to the UT&D SS and the 1108s. Operation of the remainder of the Tracking System is the same as described for the 26-m-diameter antenna subnet.

3. DSN/MM '71 Command System. The DSN/MM '71 Command System generates and transmits commands to the MM '71 spacecraft. All related verification, display, and control functions are incorporated within the system to ensure and confirm successful command operations. The SFOF generates MM '71 command messages and instructions through Project-supplied software or specifications. MM '71 command and associated messages are transmitted in standard GCF formats via HSDL at 4800-bits/s data sets. A backup mode of operation to the HSDL consists of voice or TTY transmission of command messages and instruction information to the DSS for manual keyboard insertion into the TCP.

a. MM '71 command generation and processing. Following is a general description of MM '71 command generation, processing, and transmission:

(1) Command message. The command message contains the command data along with DSIF Telemetry and Command Subsystem processing instructions, time of execution, and accountability information.

This command message originates in the SFOF Mission Support area and is displayed in the SFOF Mission Support and Command Operations Analysis Group areas.

(2) Command verification message. This message is a repetition of the command data except for a reversal of the source and destination codes. This message is sent automatically upon receipt of a command message by the DSIF Telemetry and Command Subsystem and is displayed in the SFOF Mission Support and Command Operations Analysis Group areas.

(3) Command instruction translate table input message. This message contains the actual command data to be preloaded into the DSIF Telemetry and Command Subsystem along with processing and accountability information. The DSIF Telemetry and Command Subsystem automatically returns a repetition of this message to the SFOF, except for reversal of source and destination codes. This instruction originates in the SFOF Mission Support area and will be displayed in the SFOF Mission Support and Command Operations Analysis Group areas.

(4) Command instruction configuration table input message. This message contains information to automatically configure the DSIF Telemetry and Command Subsystem for a particular mission. The DSIF Telemetry and Command Subsystem returns a repetition of this message to the SFOF, except for reversal of source and destination codes. This instruction message is originated in the Command Operation Analysis Group area and is displayed in the SFOF Mission Support and Command Operations Analysis Group areas. Explicit in this message are mode instructions, frequency shift (if applicable), modulation abort limits, and command symbol rate.

(5) Command instruction standards and limits message. This message is sent from the SFOF to the DSIF and contains both DSN and project-supplied standards, with attendant limits, to enable the DSIF Telemetry and Command Subsystem to automatically monitor its operation. The DSIF Telemetry and Command Subsystem returns a repetition of this message to the SFOF, except for reversal of source and destination codes. This message is originated in the Command Operation Analysis area and is displayed in the SFOF Mission Support and Command Operations Analysis Group areas. Such standards as maximum time of execution, frequency shift limits, symbol rates, exciter frequency, and spacecraft numbers are contained in this format.

(6) Command enable/disable message. This message is sent to the DSIF from the SFOF and lists processing instructions for the DSIF Telemetry and Command Subsystem's storage of commands. The DSIF Telemetry and Command Subsystem returns a repetition of this message to the SFOF, except for reversal of source and destination codes. This message originates in the SFOF Mission Support area and be displayed in the SFOF Mission Support and Command Operations Analysis Group areas.

(7) Command confirm/abort message. This message contains confirmation on the results of processing commands by the DSIF Telemetry and Command Subsystems. This message originates automatically at the DSS and is displayed in the SFOF Mission Support and Operations Analysis Group areas. It contains command accountability and time of first bit transmission or abort reason code.

(8) Command recall request message. This message interrogates the DSIF Telemetry and Command Subsystem for current status as to configuration, standards and limits, command and translate table stacks, and system checks. It originates in the SFOF Mission Support area and is displayed in the SFOF Mission Support and Command Operations Analysis Group areas.

(9) Command recall response message. This message is the answer to the recall request message. It originates in the DSIF Telemetry and Command Subsystem and is displayed in the SFOF Mission Support and Command Operations Analysis Group areas.

(10) Command alarm message. This message contains system alarms and is originated automatically by the DSIF Telemetry and Command Subsystem. It is displayed in the SFOF Mission Support and Command Operations Analysis areas.

b. <u>DSN/MM '71 Command System, 26-m-diameter antenna subnet operation</u>. As shown in Table 26 and Fig. 31, MM '71 commands from the SCF/1108 COMGEN program or from a manual keyboard (2260) enter the SFOF CPS 360/75, where they are processed into command messages for transmission to the DSIF TCP (TCD-SS) over the 4800-bits/s HSDL. Manual backup commands are also entered into the TCP by the 920 keyboard at the DSS. A voice or TTY circuit for coordination of manual backup commands connects the SFOF operational areas with the Station Manager console in the DSIF Monitor and Control subsystem. SFOF- or DSIF-generated command bits, one spacecraft at a time, are fed at 1 bit/s into the command waveform generator and mode control, where they are converted into the command modulated subcarrier signals, which are fed to the exciter. The modulated S-band carrier is generated in the exciter and fed to the transmitter subsystem where it is amplified to 10 kw; it is then transmitted to one spacecraft at a time through the microwave antenna subsystem. Spacecraft AGC, SPE, and command lock which are required to verify command readiness are stripped from the engineering telemetry data by the TCP and passed to the Station Manager console.

c. DSN/MM '71 Command System, DSS 14 operation. As shown in Table 27 and Fig. 32, operation of the Command System at DSS 14 is the same as that of the 26-m-diameter antenna subnet except for the following features:

(1) Two TCPs, command-confirmation receivers, command waveform generators, and exciters providing dual transmission capability.

(2) On a best-efforts, R&D basis, 400-kW output (with no backup generator) modulated S-band carrier to one spacecraft, or dual 40-kW transmission.

(3) On a normal basis, 20-kW output with backup generator for modulated S-band carrier to one spacecraft.

4. DSN/MM '71 Simulation System. The DSN/MM '71 Simulation System is designed to generate simulation and checkout data and to control the insertion of those data into the DSN for the purpose of preparing the DSN and its users for the support of MM '71 Mission Operations.

The DSN/MM '71 Simulation System elements and flow paths of simulation data through the DSN are shown in Table 28 and Fig. 33. The GCF is used for distribution of simulation data to the SFOF and DSS. The DSN Simulation Center at JPL, together with the DSIF Simulation Conversion Assembly at each DSS, are the principal elements of the DSN/MM '71 Simulation System.

a. Modes of operation. The DSN/MM '71 Simulation System provides two modes of operation, as follows:

(1) SFOF input (short-loop) mode. In the SFOF input (short-loop) mode, the DSN SIMCEN processes simulated MM '71 spacecraft and DSS data into GCF messages for input to the SFOF so that the data appear to be coming from the DSIF. Command messages and standards and limits from the SFOF that would ordinarily be received at the DSIF are received and processed in the SIMCEN when the system is in this mode.

(2) DSIF input (long-loop) mode. In the DSIF input (long-loop) mode, the DSN/MM '71 SIMCEN injects data into one or more DSS. Simulated spacecraft data require on-site conversion from GCF message format into signals of the kind expected from the MM '71 spacecraft in flight. Concurrent SFOF messages to the DSS which are generated in other systems are multiplexed by the GCF onto HSDL and are inserted directly into the respective DSIF systems that ordinarily receive data or instructions from the SFOF. The incoming HSD from the DSIF to the SFOF are parallel-routed to the SIMCEN for extraction of command and monitor data.

b. DSN/MM '71 Simulation System operations. Data are transferred from MM '71 math models in the 1108 to the 6050; control information data are transferred in both directions. Details on the MM '71 Project-supplied input and output processing are presented in Table 28 and Fig. 33. The operation is as follows:

(1) Simulation data, HSD format. Mariner Mars 1971 simulated telemetry data, formatted for HSD, are sent for long-loop simulation from the 6050 in the SIMCEN to the DSIF SCA 910 computer of the Telemetry and Command Data Handling Subsystem (TCD), via the GCF 4800-bits/s HSDL. The SCA has several alternative points for inserting the data into the Telemetry System.

For short-loop simulation, MM '71 simulated data are sent directly to the MTC and the 360/75. The simulated HSD consists of two engineering data streams (8 1/3 or 33 1/3 bits/s), two 50-bits/s science data streams or one 50-bits/s science data stream and one high-rate science data stream (1 or 2 kilobits/s), bit rate, subcarrier frequency, attenuation and modulation index control, and simulation instructions.

(2) Simulation data, WB format (DSS 14 only). Simulated MM '71 high-rate data (4 kilobits/s and above) are sent for long-loop simulation from the 6050 in the SFOF to the DSS 14 SCA of the TCD 910 computer, via the GCF 50-kilobits/s WB line and terminals. The SCA then inserts the data into the DSS 14 Telemetry System.

For short-loop simulation, MM '71 simulated high-rate data are sent directly to the MTC and the 360/75. Simulated HSD, formatted for wideband transmission, consist of one 16-kilobits/s (max) high-rate data stream when transmitted to DSS 14, or two (max) 16-kilobits/s high-rate data streams when short-looped directly to MTC and the 360/75. Two data streams to DSS 14 will be attempted, depending upon SCA capability.

(3) Simulated data, tracking. TTY-formatted simulated tracking data (100 words/min) from three simulated DSS (either spacecraft from any DSS) are output from the 6050 in the SIMCEN/SFOF through the CP in the GCF to the SFOF/MM '71 Tracking System, providing short-loop simulation only.

(4) SCA of TCD, DSS of DSIF. In the DSS SCA 910, simulated MM '71 HSD and WB data (DSS 14 only) are processed and output by either or both of two subprograms:

(a) Real-time subprogram. Output processing includes up to four data channels. These four data channels are fed through bit-stream regeneration to subcarrier modulation, Symbol Synchronizer Assembly (SSA), and TCP for both spacecraft. From subcarrier modulation the data are fed through a sum device, which is controlled by the mixing ratio (modulation index) control signal out of the DSS SCA 910 to the spacecraft

SDAs (for S/C 1 and 2) and the receiver/exciter subsystems.

(b) Data generation subprogram. Output processing includes up to four data channels. The data source is a stored pattern in the SCA, instead of HSD or WB.

(5) Receiver/Exciter Subsystem, DSS of DSIF. From the SCA subcarrier modulation and sum devices, data for each spacecraft are fed into each of the two carrier-generation devices in the station receiver/exciter subsystems, which output a modulated S-band carrier for each simulated spacecraft. Each modulated S-band carrier is fed through a signal-level attenuator device which is controlled by signals from the SCA 910 computer using either program. The equivalent of the spacecraft signal then flows from the signal-level attenuator, as output from the DSN/MM '71 Simulation System, to the DSN/MM '71 Telemetry System.

5. DSN/MM '71 Monitor System. The DSN/MM '71 Monitor System provides status sensing capabilities of certain key elements of the DSN, processes and displays these data for use by DSN operations personnel, and stores these data for later analysis or reference. Monitor data are used for determining network status and configurations, for guidance in directing DSN operations, for furnishing alarms of nonstandard conditions, and for supporting data quality and quantity analysis which is provided to the MM '71 Project.

DSN monitor data are defined as a selected subset of the machine-accessible facility monitor data that reports identification, state, performance level, configuration, loading, utilization, or change in value of any of these parameters for those operationally active elements of the DSN that have monitoring provisions.

Monitor Criteria Data (MCD) are defined as any machine-accessible standard or limit applicable to DSN or facility monitor data.

DSN/MM '71 Monitor System data flow is given in Table 29 and Fig. 34 for prime stations providing MM '71 support. This diagram includes elements of the three DSN facilities: DSIF, GCF, and SFOF; Deep Space Stations 12, 14, 41, 51, and 62 are the stations included.

The DSN/MM '71 Monitor System functionally resides in four processors, one for each facility, and one for the network. Each facility monitor processor accepts configuration reports, load factor, performance information, and status from facility instrumentation, and also accepts reports on data accountability and quality from the Tracking, Telemetry, and Command System error detectors. A facility analysis program compares actual versus standard configuration, load, status, accountability, and quality, and then sends alarms of nonstandard performance to facility control and the DSN Monitor System.

Communications system performance parameters measured at the DSS are reported to the DSIF and GCF monitor. The DSN monitor processor provides analysis of all monitor data affecting more than one facility or system and alarms the MM '71 DSN system operations analysts. Data for more detailed analysis of nonstandard performance are also available from the DSN monitor processor. Alarms are routed to the system involved and to the DSN/MM '71 operations control team. Reports on performance data are made to facilities and systems as required. Raw standards and limits are gathered from each facility and from each DSN systems analyst and processed against a single instrumentation catalog for use by facilities in their system error detectors. A DSN status Master Data Record (MDR) is made by the monitor operations group from recorded monitor data.

DSS system data alarms and status are input to the DSIF monitor computer. Instrument status and time from other DSS subsystems are also input to the monitor computer as well as some DSS standards and limits from SFOF. Input and internal processing of DSIF monitor computer data are detailed in Fig. 34.

DSS status are output from the DSIF monitor computer through the GCF via BMXR, EDED, and HSDL 4800-bits/s data set to the 360/75 in the SFOF. Output processing in the DSIF monitor computer for the DSS status data is detailed in Fig. 34.

The inputs to the CP from the GCF Error Detection Encoder Decoder are the GCF HSD instrument alarms for all high-speed traffic inbound to SFOF. Outbound from the CP are the GCF instrument status and data status to the 360/75 in the SFOF, plus the GCF instrument alarms formatted for GCF Control TV display. Also input to the 360/75 are time and data alarms detected by the SFOF and GCF Tracking, Telemetry, and Command Systems, and those indicated by periodic processing status messages.

Output and input between the SFOF 360/75 and the UT&D SS are the Monitor program/operator interplay plus status displays. Output from the 360/75 in the SFOF to the DSIF monitor computer, through the GCF-HSDL 4800-bits/s data set with BMXR and BDXR, are some DSS standards and limits (predicts, etc.). A DSN status MDR is produced from recorded DSN/MM '71 monitor data out of the 360/75.

6. DSN/MM '71 Operations Control System. The DSN Operations Control System is the mechanism for directing the operation of the DSN Systems and facilities in support of flight projects. The function of operations control is effected by the DSN Operations Chief through Facility Chiefs according to plans, procedures, and sequences, and real-time direction in the event of anomalous conditions, to provide optimum support to flight projects.

The Operations Control System includes the following support functions:

(1) Network Systems Operations Group.

(2) DSN Scheduling System.

(3) DSN Discrepancy Reporting System (DRS).

(4) DSN Sequence of Events (SOE) Generation.

(5) DSN Status Master Data Records (MDR) production.

(6) DSN Operational Document Control.

(7) DSN Facility Operations Chiefs.

a. DSN/MM '71 Operations Control System operation. The DSN Operations Control System relationship to the flight projects, other DSN systems, and DSN facilities is shown in the conceptual block diagram of Fig. 35 (consider MM '71 as Flight Project 2). This drawing has been simplified as follows:

(1) The interface for Mission Control inputs to the DSN Command System is not depicted.

(2) The DSN Simulation System is considered as an exact replica for the spacecraft and the DSN Tracking, Telemetry, and Command Systems during testing.

Products of the DSN are the facility and network systems services and the recorded data generated and collected by the DSN Tracking, Telemetry, and Command Systems. These data are validated by the DSN Systems Operations Groups and are delivered to project analysts for execution of mission objectives. In addition, the data are processed into the DSN MDR and delivered to the Project.

The Project Analysts provide information about the spacecraft to Mission Control, which in turn requests, if necessary, that DSN Operations Control take appropriate action. In a similar manner, DSN status is reported to Operations Control by the Monitor System, the DRS, the DSN facilities, and the DSN System Operations Analysis Groups. From DSN status analysis and with previous planning, the DSN Operations Control System can respond to the Project request with direction and control to the DSN Systems and facilities.

Figure 36 shows the DSN Mission-Independent Operations Organization, which is also used for MM '71 mission-dependent operations. Supporting elements of the mission-independent operations organization include four specialized and unique functions: (a) DSN Scheduling System, (b) DSN Discrepancy Reporting System (DRS), (c) DSN Sequence of Events Generator (SEG), and (d) DSN Operational Document Control.

b. DSN Operations Control Network Allocation System (DSN Scheduling System). The scheduling system is one of the mechanisms of the DSN Operations Control System for directing the DSN systems and facilities in support of flight projects. Within its jurisdiction are the identification and resolution of conflicts, using established priority guidelines, including those given by NASA. The scheduling system provides the DSN scheduling interface with other NASA agencies. Two modes, a non-real-time mode and a real-time mode, are characteristic of the scheduling system (Fig. 37). The non-real-time mode consists of a 72-week schedule, a mid-range schedule, and a 7-day schedule.

c. DSN Discrepancy Reporting System. The DSN DRS is a DSN-wide system of the documentation of failure reporting, emergency analysis and management; the standards covering its operations are contained in JPL internal document 810-2, Deep Space Network Discrepancy Reporting System, Jet Propulsion Laboratory, Pasadena, Calif., Sept. 15, 1968.

d. DSN Sequence of Events Generator. The Operations Control System automates, standardizes, and centralizes DSN SOE generation. The DSN obtains from MM '71 Project SOEs the line items needed to insert into the DSN/MM '71 SOE. The mechanism of data flow across Project interfaces is machine language as well as the printed page. The DSN operates exclusively from DSN SOEs that have adequate Project SOE line items. Basic characteristics and constraints are centered around the DSN computer program that supports this function. Details on the DSN SOE system are presented in JPL internal document 820-6, Rev. A, DSN System Requirements, DSN Operations Control System (Through 1971), Jet Propulsion Laboratory, Pasadena, Calif., May 1, 1971.

e. Operations Control diagram. The DSN/MM '71 Operations Control System for all stations is described in Table 30 and Fig. 38. Keyed footnotes precede the diagram so that both can be viewed simultaneously.

D. DSN Facility Configurations

In the remaining paragraphs of this Section, those facility capabilities and subsystems which are not adequately described in the preceding paragraphs are covered. All facility subsystems will not be covered here; only those which span more than one network system and those which are new or unique for MM '71 will be described.

1. Ground Communications Facility. An overview of the DSN communications network, together with significant GCF system applications, for Project support are presented in the following paragraphs. Requirements and configurations of the GCF which relate only to orbital-phase mission support will be documented in Vol. III of this Technical Memorandum, although certain requirements were indeed implemented and tested before launch.

a. Overall communications network. The majority of GCF transmission capability is furnished by NASCOM from a pool of circuits used to satisfy all NASA worldwide deep-space communications requirements. Certain communication circuit quantities to specific Project support agencies are Project-dependent by virtue of the geographic area in which the agency is located. Circuits to Project-supporting elements at Cape Kennedy are an example of such Project-dependent requirements. The communications network shown in Fig. 39 represents the circuit quantities and routing to supporting elements of the DSN and MSFN as well as Project-dependent requirements at Cape Kennedy.

Existing capability within GCF Voice and TTY Systems was employed without change. Only the GCF HS and WB Systems are discussed as they

share the major GCF contribution to the ground data system insofar as facility engineering and implementation are concerned.

b. High-Speed System. A new design of the GCF High-Speed System (HSS) became a clear requirement during development of DSN Systems planning for the capability to support both the MM '71 and Pioneer F and G Projects. Several constraints and tradeoffs were considered in determining the design for which new items of equipment were required. Implementation was carefully controlled, since much of the activity coincided with upgrading the NASCOM HSS. The GCF provided the design and implementation by the fourth quarter of calendar year 1970.

Increased capacity of high-speed communication channels between DSN stations and the SFOF was required to support the DSN multi-mission concept. Requirements of the six DSN Systems exceeded the existing 2400-bits/s station capacity. NASCOM was also planning 4800-bits/s capacity, and flight projects in the 1973 era would further increase HSD traffic. By October 1969, the decision was made to convert the GCF HSS to 4800-bits/s data sets. The implementation schedule was keyed to the delivery of 203A data sets from NASCOM, since extensive changes were being made in the NASCOM switching centers at Madrid, Canberra, and GSFC. Figure 40 illustrates the functional block diagram for the design. To accommodate the 4800-bits/s data sets, some additional modifications were also made to the internal logic of existing equipment.

In a parallel effort, two test programs were developed to check out the system on a station-to-station basis. These programs provided a source of known HSD blocks, formatted in accordance with DSN-GCF standards, and transmitted from an SDS 920 computer at the station or from the 360/75 computer at the SFOF. Simultaneously, programs at each end analyzed incoming data blocks, providing bit error rate data from which system performance could be determined.

Early tests indicated that system performance was in accordance with specifications. By mid-November 1970, all prime MM '71 stations were ready to support DSN system tests. Within the next 4 months, remaining DSN stations completed installation and acceptance checkout tests to bring the total system into full operation.

c. Mission-dependent interfaces with High-Speed System. Excluding the interface with the University of Colorado at Boulder, to be used during orbit phase, there were three mission-dependent interfaces with the high-speed system, each of which presented HSD to mission-dependent data processors at different locations. One of the interfaces supported launch activities and the first few days of spacecraft cruise operations. Attributes of each interface are as follows (also shown collectively in Fig. 40):

(1) MOS "Green Box" interface at SFOF. Six receive-only digital HSD channels were broadcast to the MOS green box installed in the Spacecraft Team Area within the SFOF. Each channel presented to the green box consists of received data, receive timing, and data carrier detected signals, each of which originates from the block multiplexer(s) at SCT. Spacecraft Team Analysts, using appropriate GCF user status and configuration displays, determined HSD channel selection and switched the selected channel to the green box input.

(2) MOS MTC interface at SFOF. Six receive-only digital HSD channels were broadcast to the MTC in the same manner as those HSD channels presented to the green box. HSD channel selection was premised upon user examination of the appropriate GCF user display.

(3) MOS MTC interface at Cape Kennedy. The Cape Kennedy MTC receive-only HSD terminal was comprised of a 203A data set and Fredericks Model 600 data test set provided by NASCOM. A data quality communications circuit between Building AO at Cape Kennedy and the NASCOM primary switching center at GSFC was provided by NASCOM for use with the terminal.

The interface with the Cape Kennedy MTC was necessarily a single channel of received digital HSD (received data, receive timing, data carrier detected, etc.) originating from a particular tracking station data source. During prelaunch spacecraft testing and subsequent near-Earth and early cruise phases of the mission, HSD from tracking stations was parallel-fed to the Cape Kennedy MTC in a sequential manner as explained in Subsection d below. The selection criteria depended upon overall quality of spacecraft telemetry received by tracking stations and, of course, the interrelationship of tracking station spacecraft view periods.

d. Real-time HSDL switching at GSFC. Upgrading of the high-speed system and operational peculiarities of the 203A data set required a detailed HSD patching scheme for MM '71 support. The purpose of the patching scheme was to provide a continuous stream of real-time spacecraft telemetry to the Cape Kennedy MTC during the extremely critical near-Earth phase.

In comparison, MM '69 also required a parallel feed of HSD to mission-dependent data processors at Cape Kennedy (Fig. 41). This requirement was comparatively simple to accommodate, whereas the same functional requirement levied upon the TDS by MM '71 demanded that all aspects be closely examined in light of the following factors:

(1) Expanded scope of MSFN near-Earth phase tracking support: Four tracking stations (Merritt Island, Bermuda Island, Canary Island, Ascension Island) and one AIS (Vanguard) as compared with only Ascension Island supporting MM '69.

(2) Operating characteristics of the 4800-bits/s 203A data set precluded parallel patching of HSD at the audio baseband level. The data set transmitter

automatically training/retaining the distant data set receiver requires the use of an uninterrupted full duplex data communications circuit. Patching the audio baseband would clearly upset this interface necessary for proper data set operation.

(3) Time-critical elements of the sequential patching itself when considering both (1) and (2) above.

The 203A data set patching configuration finally arrived at required that all patching be performed at digital levels; that is, between regenerating data sets at GSFC. Parallel feeding at SFOF of HSD from Goldstone required a minor variation from the standard digital patching at GSFC, but the overall concept was functionally the same.

In summary, a single plug patch cord of the tip, ring, sleeve variety was used to access the 203A data set "receive line" monitor jack for the incoming data to be regenerated as depicted in Fig. 42. The receive line monitor jack presents the received data, "receive" timing, and data carrier detected associated with the incoming data. The third data set was then configured to respond to an external clock source: receive timing from the receiving regeneration data set. The same patch cord was then patched to the third data set transmit line jack thus that data set reacted as if it were part of a discrete regeneration channel. The third data set audio baseband output then was patched to the data communications circuit destined to appear at the Cape Kennedy MTC HSD terminal 203A data set.

The operational simplicity of the parallel-feed data set configuration resulted from the use of a single patch cord which all but obviated any possible operator error. Communications personnel were required only to patch each receiving regeneration data set in a sequential manner shown in Fig. 43.

e. Wideband System. The mission-independent application of the Wideband Digital Data System, essentially the GCF system prototype of which MM '71 is the first user project, was engineered and implemented before launch. Only the mission-dependent application of the system, which supported prelaunch testing and NEP activities, will be discussed below.

The MOS required that the TDS provide the capability for interprocessor data transfer between the Cape MTC and the SFOF MTC in support of prelaunch spacecraft performance validation and the subsequent NEP. It was determined that, to transfer data traffic load efficiently and without costly I/O buffering, a data channel with a rate capacity of 50 kBPS would be required.

The capability finally settled upon provided a full duplex, 50-bits/s synchronous data communications channel using 303C data sets as the primary communications terminal equipment at the SFOF Communications Terminal (SCT) and at Building AO at Cape Kennedy. The necessary digital interface was provided the MTC at each location. The overall channel comprised two wideband circuits interconnected and regenerated at GSFC using 303C data sets as shown in Fig. 44.

Although there were no NASCOM performance/design goal standards available for wideband communication circuits, GCF expected the overall channel to yield an error rate of 3×10^{-5} or better on a 24-h time span basis. Random bit-error-rate checks performed under controlled conditions by communications operating personnel revealed that the long-term bit error rate was approximately 1×10^{-5}, which is clearly better than the 3×10^{-5} rate established arbitrarily by GCF.

2. DSIF Analog Playback Facility. The DSIF Compatability Test Area (CTA 21) was used to operationally support MM '71 in two roles:

(1) Conversion of analog recordings of occultation data from DSSs 41 and 62 to a digital form in order to be computer compatible.

(2) Playback of predemodulation analog telemetry recordings, through a subcarrier demodulation assembly, to produce digital recordings identical to the DSIF produced telemetry ODR.

The configuration for the analog playback capability, serving both the telemetry and occultation data requirements, is shown in Fig. 45. The FR 2000 analog record/playback device provided, with high time-base stability, an analog telemetry input to the subcarrier demodulator assembly. Subsequent telemetry processing was identical to the processing at any DSS; demodulation was performed by the SDA; symbol synchronization was performed by the symbol synchronization assembly; and an original data record digital recording was written by the telemetry and command processor. Although not planned for operational usage, the data could be sent directly to the SFOF IBM 360/75 computer via high-speed (4800-bits/s) or wideband (50,000-bits/s) data lines. It should be mentioned at this point that predemodulation recordings could not be replayed directly from the receiving DSS as could postdemodulation recordings, because of a time-base stability problem; only DSS 14 and CTA 21 have the FR 2000 record/playback devices. It was planned to use this capability only when the SDA had failed and the data was required for the master data record.

The FR 2000 was also used to play back recordings of open-loop receiver data for the Mariner Mars 1971 occultation experiment. DSS 14 had an on-site digitization capability, but DSS 41 and 62 did not. Recorded data from the latter stations was played into a mini-computer (the data decoder assembly, which is normally used for other purposes) after filtering and undergoing analog-to-digital conversion. The format of the DSS 14 and the CTA 21 recorded tapes was identical.

3. SFOF User Terminal and Display Subsystem. The User Terminal and Display Subsystem (UT&D SS) included 2260 I/O consoles (both with and without 1052 input keyboards), 1443 line printers, 2501 card readers, digital television (DTV) channels, DTV hard copy units, DTV format

request boxes, and character printers. Table 31 shows the number of devices provided to MM '71.

a. 2260 I/O consoles. The 2260 I/O console, model 2, displayed up to 12 lines of 40 characters on a CRT. The machine used a nondestructive cursor, line addressing, and an antireflective display screen. The data entry keyboard contained alphanumerics and control keys required to format and enter data. The 2260 received video signals through an IBM 2840 display control station.

b. 1443 line printer. The 1443 printer, model N1, employed a 63-character set that printed 144 characters per line at 200 lines per minute.

c. 2501 card readers. The 2501 card reader, model B, had a 600-card-per-minute maximum card reading rate, a 1200-card hopper, and a 1300-card stacker.

d. DTV Assembly. The DTV assembly interfaced with the two 360/75s and was a part of the SFOF UT&D SS. The DTV assembly provided SFOF with a flexible real-time and near-real-time data display system. This display system provided multi-channel computer-generated displays of alphanumeric and graphic information (40 or 80 characters per row and 20 or 40 rows) to support MM '71. Information was displayed for data analysis, decision making, monitoring, and management visibility.

The displays were shown on various 9- or 14-in. TV monitors throughout the SFOF. When any permanent copies of the displays were requested, six printers, each with a request unit, were available to print hard copies of the selected displays.

4. SFOF Mission Support Area. The MSA configuration for MM '71 is shown in Figs. 46 – 50.

5. Tracking System Analytic Calibration (TSAC). The calibration of radio metric data to account for certain observer-related phenomena is necessary to meet more stringent navigation requirements. In order to extract an optimum amount of information from this data, it must be processed to remove, as much as possible, any bias or random noise effects which may have corrupted it. Currently, several error sources have been identified as contributing significantly to the composition of the noise signature. These observer-related errors can be classified into two main categories:

(1) Errors in locating the observer (tracking station) with respect to the inertial space: DSS locations with respect to the earth's crust, polar motion, and variation in earth rotation rate (A.1 – UT1).

(2) Errors caused by the transmission media that corrupt or distort the actual information content of the observation: charged particle effects (ionosphere and space plasma) and neutral particle effects (troposphere refraction).

The refractive effect of the troposphere causes the retardation and bending of an electromagnetic beam. This makes the observation appear as if the beam has traveled through a longer distance. This difference is such that radio measurements of range and doppler are significantly affected. The model currently used to measure the effects of refractivity assumes a fixed distribution of refractivity in the atmosphere over each site. Actually, the refractivity distribution goes through seasonal and diurnal changes which, if not properly detected, can cause errors in estimating the location of a spacecraft. To eliminate this error, two tropospheric models will be employed which account for the different seasonal variations of the wet (including water vapor) and the dry components of the troposphere.

The radio signals traveling between a tracking station and a spacecraft pass through the charged-particle media of the interplanetary space plasma, the ionosphere of the earth, and possibly the ionosphere of other planets. The interaction between the radio signal and the charged particles in the medium causes an increase in the phase velocity and a decrease in the group velocity.

The earth's ionosphere is caused by ultraviolet light from the sun ionizing the upper atmosphere. Consequently, the ionosphere above a fixed location on earth increases and decreases with, roughly, a diurnal period. If the ionospheric effect cannot be measured or modeled, it cannot be distinguished from errors in tracking station location and may result in significant errors for in-flight orbit determination.

The space plasma effect is due to streamers of electrically charged particles emanating from the sun that intersect the radio tracking beam to the spacecraft. The effect on the radio beam is similar to that described for the ionosphere, except that the electron activity in interplanetary space is more of a steady-state nature, with fluctuations occurring mainly as the radio beam enters and leaves a particular streamer or as a result of sudden outbursts of plasma from solar flares.

The total charged-particle effect, that is, the effect of both the ionosphere and space plasma, can be measured by techniques such as dual-frequency transmission and the comparison of the doppler and ranging signals. This latter method is used for the Mariner Mars 1971 mission. It involves no extra hardware for the spacecraft.

This method makes use of the differential between phase and group effects in a charged-particle medium. Since doppler depends on phase propagation and ranging on group propagation, a comparison of differenced range versus integrated doppler yields the time rate of change of the error due to variations in the total columnar charged-particle content. This quantity can be used directly to correct doppler for charged-particle effects.

a. Requirements. The Mariner Mars 1971 Project placed the following accuracy requirements on the DSN:

DSS location[a]	$\sigma_{r_s} = 0.5$ m and $\sigma_\lambda = 1.0$ m
Polar motion[a]	$\sigma_x = 0.7$ m and $\sigma_y = 0.7$ m
Variation in Earth rotation period[a]	2.5 ms
Neutral particle effects	0.5 m
Charged particle effects	1.0 m

[a]The DSS provides analytic calibration assistance to the project in order to achieve these accuracy requirements.

b. TSAC Capabilities. The calibration software is termed the tracking system analytic calibration software assembly. This assembly consists of two subassemblies residing in the IBM 360/75:

(1) The platform observables subassembly (PLATO).

(2) The transmission media subassembly (MEDIA).

The first provides calibrations for DSS location, polar motion, and the variation in the earth's rotation rate (A.1 — UT1). The second provides calibrations for the troposphere and a combined calibration for the ionosphere and space plasma using the differenced range versus integrated doppler (DRVID) technique. Figure 51 depicts the interfaces of the TSAC assembly. As shown in the figure, the data input is from two sources; the DSSs provide the DRVID observable, and the tracking operations group of the DSN operations organization inputs the required troposphere parameters, time and polar motion data, and DSS locations which have been previously prepared.

The DRVID observable is obtained via teletype or high-speed data from planetary ranging systems at DSS 14 and one 26-m-diameter antenna DSS (probably DSS 41). It is placed on the system data record by the tracking data processor. The MEDIA subassembly accesses the SDR to obtain the unprocessed DRVID data, compute the doppler corrections, fit them with a polynomial, and place the polynomial coefficients on a calibration file accessible to the double precision orbit determination program in the Univac 1108 computer. The DRVID computation compares the differenced range to integrated doppler and provides a measure of exactly that quantity required to calibrate doppler for charged-particle effects. This quantity is usually expressed in terms of the range change error $\Delta\rho_e$:

$$\Delta\rho_e(t) = \frac{c}{2}\left\{R(t) - R(t_0) - \frac{K}{f_q} \times \left[D(t) - D(t_0) - f_b(t - t_0)\right]\right\}$$

where

$R(t_0)$ = spacecraft range at initial time t_0, seconds

$R(t)$ = spacecraft range at arbitrary time t, seconds

$D(t_0)$ = cumulative doppler count at t_0, cycles of S-band

$D(t)$ = cumulative doppler count at t, cycles of S-band

$K = 96\left(\frac{240}{221}\right)^{-1}$

f_q = transmitter reference frequency, Hz (nominally 22 MHz)

f_b = bias frequency of doppler extractor 1.0×10^6 Hz

c = speed of electromagnetic propagation in vacuum, 2.997926×10^8 m/s

The MEDIA subassembly also computes a troposphere polynomial for every pass of a spacecraft over a DSS. This polynomial defines the zenith range correction to the radio beam as a function of time. The double precision orbit determination program evaluates the zenith range correction polynomial at specific times and maps the correction to the spacecraft's line of sight. The approximation to the zenith range error which is used is:

$$\Delta\rho_z = \Delta P_0\left[\frac{R}{g}\right] + \left\{\frac{C_1 C_2 (RH)_s}{\gamma}\right\}\left\{\frac{1 - \frac{C^2}{T_0}}{B - AC}\right\} \times \exp\left\{\frac{AT_0 - B}{T_0 - C}\right\}$$

where

P_0 = surface pressure, 10^2 N/m^2 (mbar)

γ = temperature lapse rate, K/305 m (K/10^3 ft)

T_0 = extrapolated surface temperature, K

$(RH)_s$ = surface relative humidity, % of 1.0

A = 77.6

B = 2034.28 ln 10

C = 38.45

g/R = 34.1°C/km

g = gravitational force

R = gas constant

C_1 = 77.6

C_2 = 29341.0

TSAC operations are shown in Fig. 52.

6. DSN occultation support configuration. The DSN configuration to support the Mariner Mars 1971 S-band occultation experiment is shown in Fig. 53. Three DSSs will be used: DSS 14 (64-m-diameter antenna), and DSSs 41 and 62 (26-m-diameter antenna). Each DSS will have an open-loop and a closed-loop receiver supporting the experiment.

At DSSs 41 and 62, doppler and digital resolver data from the closed-loop receiver are recorded on punched paper tape by the tracking data handling (TDH) subsystem at a 1 sample/s rate. The amount of data at this rate exceeds the capacity of a 100 word/min teletype circuit, so the data are played back at a lower rate to the SFOF after the end of the DSS pass. (If justified by operational priorities, the data could be played back as soon as possible after acquisition by sacrificing or delaying normal real-time tracking data.) At the SFOF, the data are processed by the SFOF Tracking System programs in the IBM 360/75 computer to produce the Tracking DSN Master Data Record. This Tracking DSN MDR is available to the Project-applied orbit determination programs operating in the Univac 1108 computer, the outputs of which, in turn, are used in the experimenter's analysis programs (also in the 1108 computer).

Closed-loop doppler and resolver data from DSS 14 follow a similar path, except that the computer-based DSIF tracking subsystem is substituted for the TDH, and shared use of a 4800-bit/s, high-speed data link is substituted for the 100 word/min teletype link. The net effect is that 10-sample/s doppler and resolver data are acquired and transmitted to the SFOF in real time for subsequent 360/75 and 1108 processing as described above.

At each of the three DSSs, open-loop receivers and ancillary equipment reduce the S-band signal to an "audio" signal with a bandwidth proportional to the change in received frequency over the period of interest. At DSSs 41 and 62, this audio signal is analog recorded and shipped to the SFOF. At the SFOF, the analog recording is used to digitize the audio signal and produce 360/75-compatible digital tapes (the occultation MDR) within 2 weeks of data acquisition.

At DSS 14, in addition to analog recording, the audio signal will be digitized in real time in a manner similar to the non-real-time conversion performed at the SFOF. This will be done to alleviate data degradation due to analog recording and playback. This digital recording will be the occultation MDR, and it will be expedited to the SFOF for entry into the experimenter's 360/75 support programs.

7. Data record configuration. One of the features of the SFOF central processing system, in conjunction with other DSN elements, is the capability for production of master data records. Experiment data records (EDRs) that apply to specific science experiments can be extracted from the MDRs. The records made as part of each system are described in the following paragraphs. The operations control system, while not described in detail here, includes the functions of central repository of MDR/ODRs and the transfer of these records to flight projects.

a. Definitions. Definitions of the various types of data records follow.

Log. Local record made at any point in the system.

Original data record (ODR). Digital log made at initial point of entry or definition of data in the system, maintained only until permanently recorded elsewhere.

System data. All data that flows within a DSN system, i.e., between the interface with the spacecraft (at the DSS antenna feed) and the interface(s) where the data is transferred to or from the user. The user in this context may be either a flight project, another DSN system, or a scientific project.

System data record (SDR). Log made at the central point of the system (one log for each DSN System). Repository is maintained until an agreed MDR transfer is accomplished.

Master data record (MDR). Records obtained, through specialized processing techniques, from the original data records. They contain the original experiment information and supporting information, such as orbital position, spacecraft attitude, and command and housekeeping data. Ground time and, where applicable, spacecraft time will have been correlated with these data. Extraneous and duplicate segments have been removed and the remainder is an organized, identified set of records, usually in digital form and capable of direct entry into a computer.

DSN MDR. Subset of the system data that the DSN provides to the project. The subset definition will be negotiated with the project. (Another log, or ODR, may be transferred as well, if agreeable and negotiated, even though such transfer may affect performance of the system.)

Experiment data record (EDR). Records extracted from the MDR to provide the principal investigator with data associated only with his experiment.

DSN EDR. Same as EDR, except that it contains only those records extracted from the DSN MDR.

b. System records. Tracking, telemetry, command, and monitor system records are discussed below.

Tracking system records. Principal tracking records are shown schematically in Fig. 54. This diagram is abbreviated to show only those portions of the tracking system that contribute to records. The primary output is the SDR, available in real time on disk or off-line on tape. This record is also by definition a DSN MDR. The MDR would consist of orbit position data computed by the project from this record. The tracking SDR (DSN MDR) contains at least the negotiated metric data (angles, doppler, and range data) plus data quality indications — such as ground configuration, statistical variations, and DSN status and performance codes. Also in the SDR are

significant event records, station location data, frequencies, and calibration parameters. The SDR may be organized according to spacecraft, and also according to other parameters, and ground transmission errors may be corrected.

Other tracking logs, as indicated in Fig. 54, are available only by recall (replay) from the recording facility. The one exception to this is the set of paper tape records made at the 26-m-diameter DSSs.

Telemetry system records. Telemetry system records are shown schematically in Fig. 55. The ODRs recorded at each station are digital recordings compatible with both DSS and SFOF computers. They contain all received telemetry data, spacecraft and station IDs, time references, and station status and performance parameters.

The backup analog tapes contain similar telemetry data, with time tags. The SDA recording is available for playback. The receiver recording is available by mail for non-DSN processing.

The telemetry SDR is a record of all received telemetry data, with data from overlapping stations merged and duplicate data removed. Data from separate telemetry streams (such as engineering and science or data from more than one spacecraft of the same project) may be merged as appropriate. The record is arranged and identified according to spacecraft and data type. It includes DSN status and performance codes and statistical data.

Command system records. Command system records are shown schematically in Fig. 56. Command ODRs are made at both the SFOF and the various tracking stations, since some of the messages are originated at each. DSS ODRs are available by mail or replay through the station. The command SDR contains at least all transmitted command data with time tags. Included also are control data, DSN status, and verification and confirm/abort data. The SDR is organized according to mission and spacecraft.

As with the telemetry system, a backup analog log can be made at each DSS. However, this log cannot be replayed through the station. Rather, it is available, by mail, for project processing.

Monitor system records. Monitor system records are shown schematically in Fig. 57. The ODRs recorded at each DSS are compatible with both DSS and SFOF computers. They contain time-tagged data on station configuration and instrumentation performance. The records contain information transmitted to the SFOF and facility monitor data of local interest only. These records are available by mail or by replaying from the station.

The ground communications facility monitor ODR is processed in the communications processor in the SFOF. The GCF status data is combined with data from other DSN systems. It contains data on high-speed data line performance and CP performance and is available by CP recall.

The SFOF monitor ODR is contained on the DSN status ODR (which is also the DSN monitor SDR). The DSN status ODR contains the DSIF monitor data transmitted from each DSS to the central processing system (CPS) in the SFOF, the GCF monitor data transmitted from the CP to the CPS, and the SFOF monitor data that originates in the SFOF and is processed by the CPS. It also contains a history of monitor criteria data (MCD) set usage and a history of all monitor alarms. The DSN status MDR is obtained by processing of the SDR.

The DSN status MDR is not normally furnished to the project per se, but an extracted subset of the data on it may be furnished to the project.

Table 17. Tracking resources for generation of C-band radar metric data

Station	Station Symbol	System Type	Comments
Merritt Island	MIL	TPQ-18	
Patrick	PAT	FPQ-6	Range Safety
Grand Turk	GTK	TPQ-18	Range Safety
Bermuda	BDA	FPQ-6	
Antigua	ANT	FPQ-6	
Vanguard	VAN	FPS-16(V)	Apollo Ship
Ascension	ASC	FPS-16	
Tananarive	TAN	FPS-16(V)	

Table 18. S-band tracking resources

Station	Station Symbol	System Type	Comments
DSN	DSS 71	DSN	Cape Area
Central Instrumentation Facility	CIF	Mandy - 7.3 -meter Parabolic Antenna	Cape Area
Hangar AE/Satellite Tracking Station	AE/STS	1.52 and 5.8-meter Antennas	Cape Area
Merritt Island	MIL	USB	
Bermuda	BDA	USB	
Antigua	ANT	TAA-3A, TAA-8A	
Vanguard	VAN	USB	Apollo Ship
Canary Island	CYI	USB	
Ascension (AFETR)	ASC	TAA-3A	
Ascension (MSFN)	ACN	USB	
Johannesburg (DSN)	DSS 51	DSN	
Tananarive	TAN	STADAN, 12-meter Antenna	
ARIA Aircraft	ARIA	2-meter Antenna	

Table 19. Summary of expected metric data support

Station	C-Band Pre-Retro	Data Post-Retro	S-Band Data After S/C Sep	Comments
Merritt Island	I			
Patrick				Range Safety Radar
Grand Turk				Range Safety Radar
Bermuda	I			
Antigua	I, II, & III			
Vanguard	I, II, & III			
Ascension	I, II, & III	II & III		
Ascension-USB			I	
DSS 51 (DSN)			I	
Tananarive		II & III		

I - Class I Requirement

II - Class II Requirement

III - Class III Requirement

Table 20. Summary of expected telemetry data support of telemetry requirements

Telemetry Site	Launch Vehicle Tlm		S/C Telemetry Via Centaur Link	Spacecraft S-Band Telemetry
	Atlas	Centaur		
DSS 71 (DSN)				II
AE/STS	I			
CIF	I	I		
Merritt Island (USB)			II	II
Bermuda (USB)		I & II	I	II
Antigua (AFETR)		I & II	I	I & II
Vanguard (MSFN SHIP)		I & II	I	I & II
Canary Island (USB)		II		I
Ascension (AFETR)		II*		
Ascension (ACN)(USB)				I
DSS 51 (DSN)				I
Tananarive (MSFN-STADAN)		II		
ARIA (AFETR)		I & II**	I & II**	

I - Class One Requirement

II - Class Two Requirement

*The AFETR Ascension telemetry station cannot track both the spacecraft and Centaur links simultaneously.

**This aircraft coverage is a backup to the critical AIS Vanguard coverage.

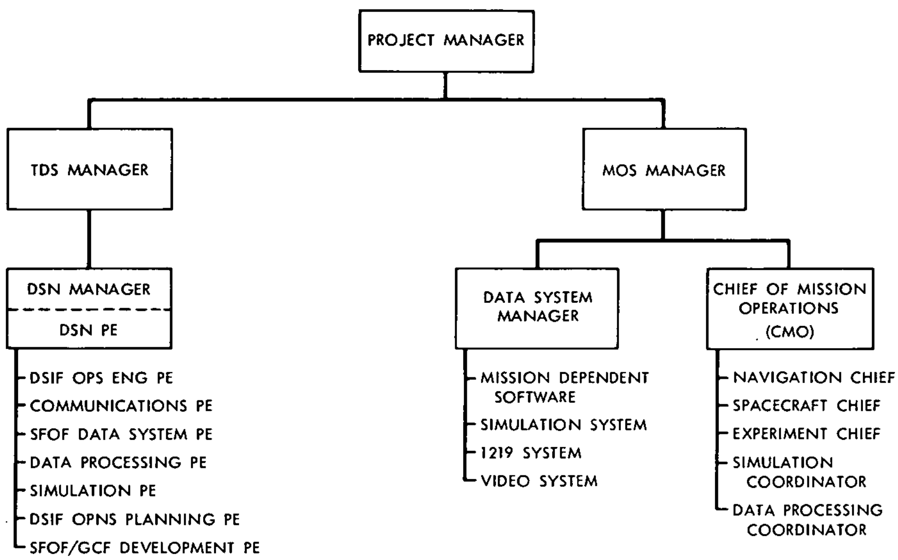


Fig. 13. Implementation phase organization

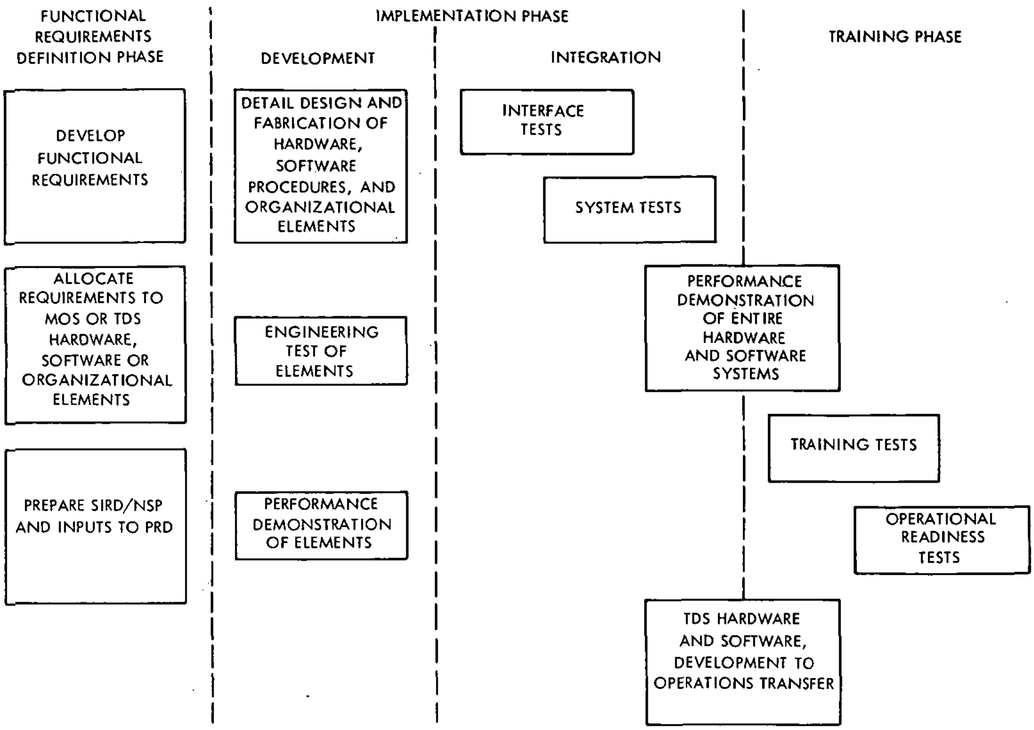


Fig. 14. Flight preparation phases

PHASE OF ACTIVITY	PRIME RESPONSIBILITY: CMO	DSN P E	DATA SYSTEM MGR
FUNCTIONAL REQUIREMENTS DEFINITION	X		
IMPLEMENTATION			
MISSION INDEPENDENT DEVELOPMENT			
DESIGN AND FABRICATION		X	
ENGINEERING TEST		X	
PERFORMANCE DEMONSTRATION		X	
MISSION DEPENDENT DEVELOPMENT			
DESIGN AND FABRICATION			X
ENGINEERING TEST			X
PERFORMANCE DEMONSTRATION			X
INTEGRATION			
INTERFACE TESTS		X	
SYSTEM TESTS		X	
PERFORMANCE DEMONSTRATION		X	
TRAINING			
TRAINING TESTS	X		
OPERATIONAL READINESS TESTS	X		

Fig. 15. Prime responsibility for flight preparation phases

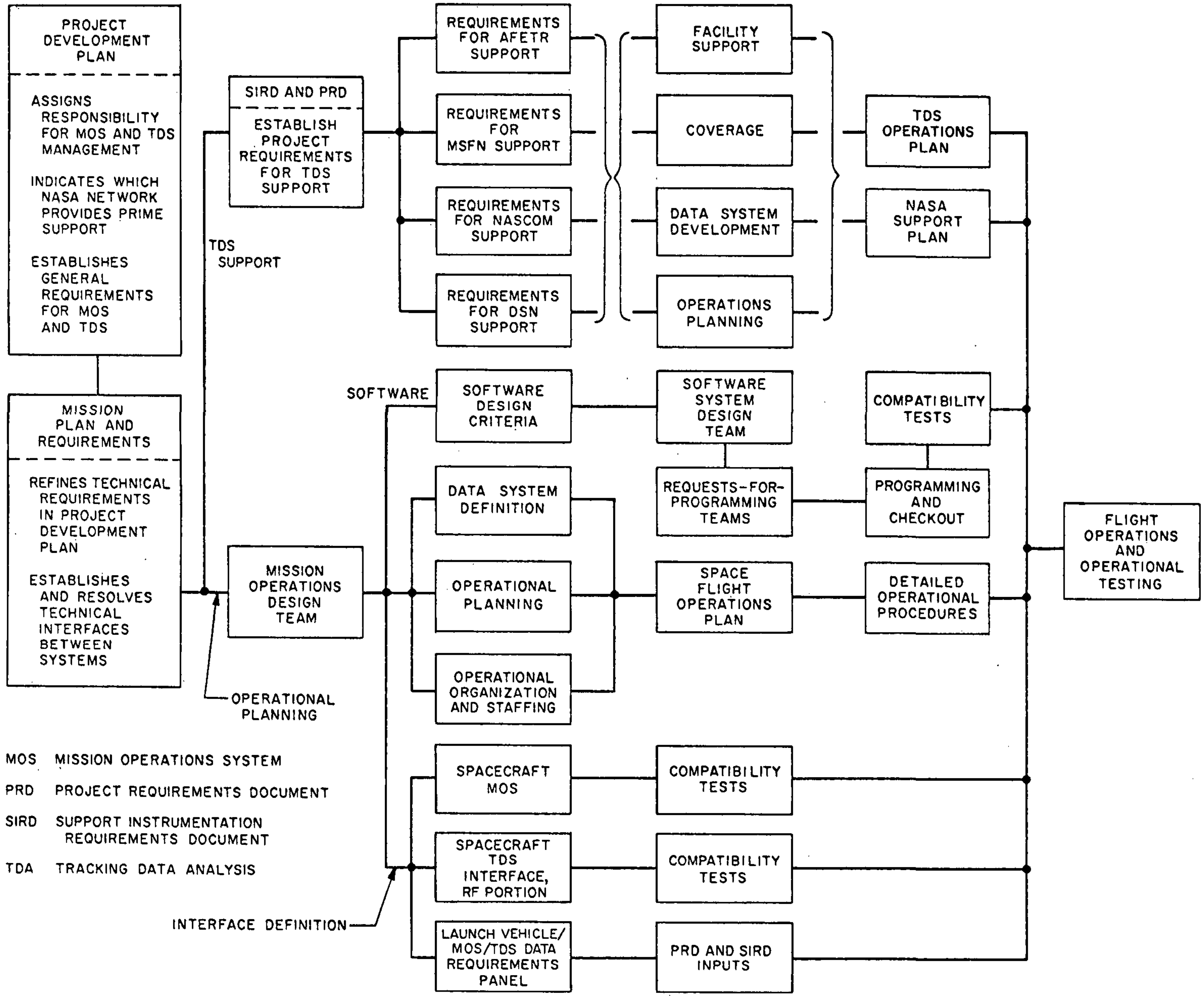


Fig. 16. Mission operations design process

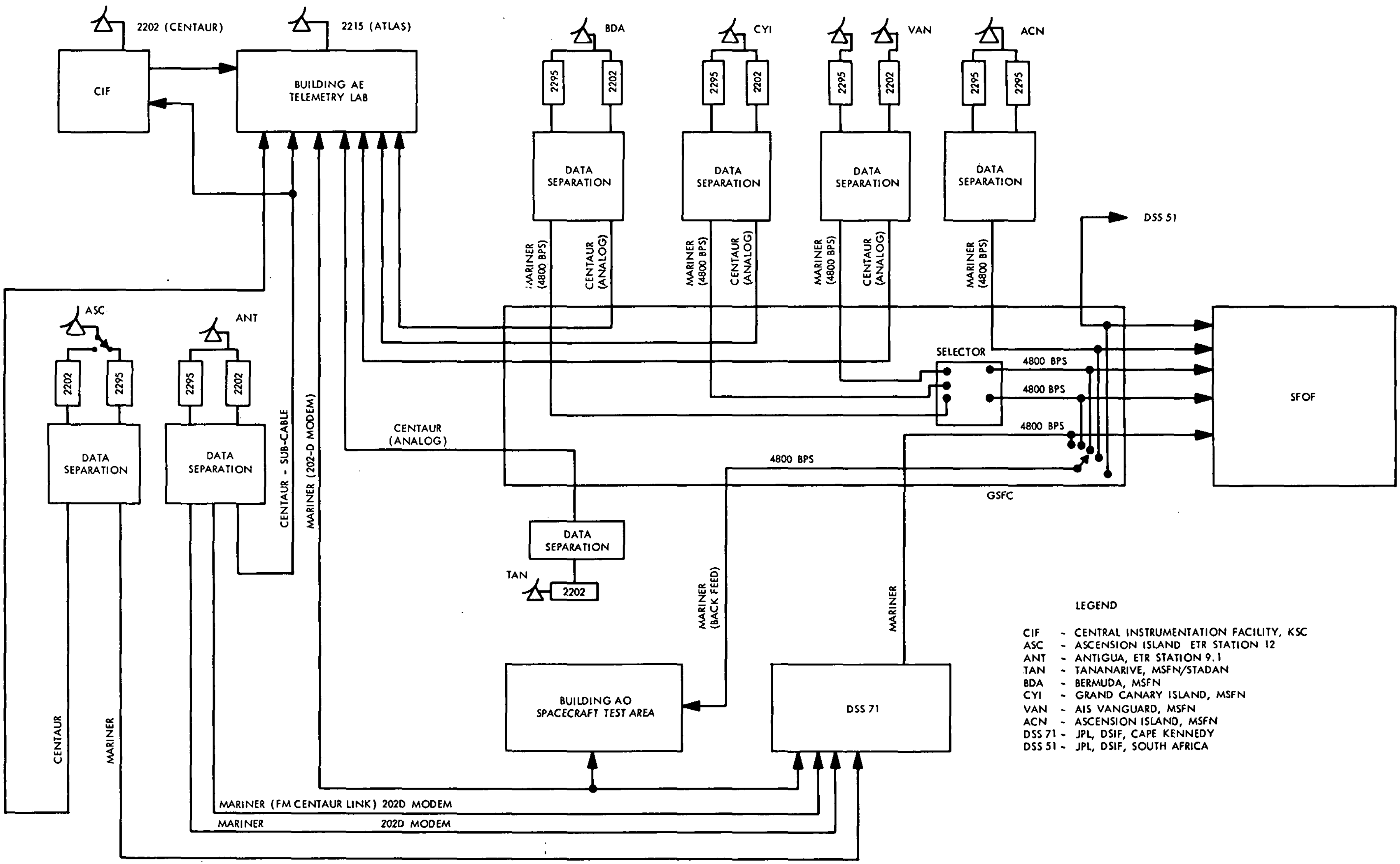


Fig. 17. Basic configuration, near-Earth-phase Telemetry System for MM '71 Project

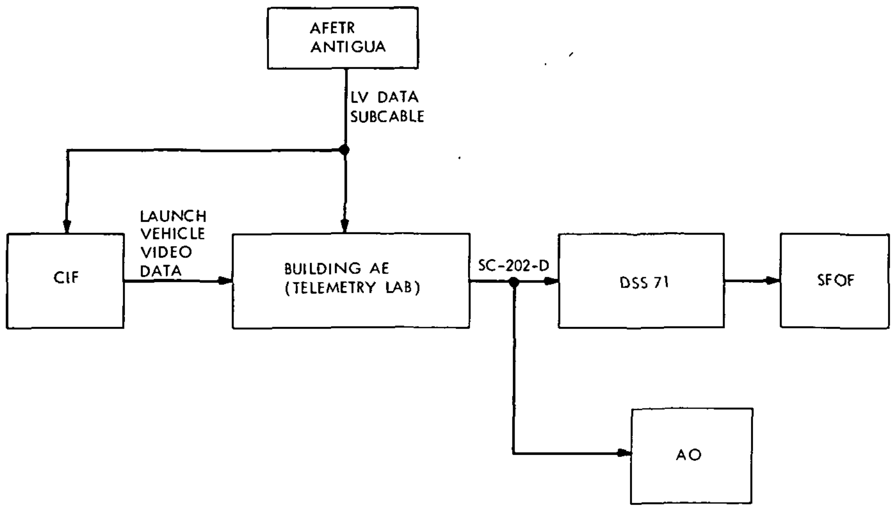


Fig. 18. Kennedy Space Center telemetry data flow

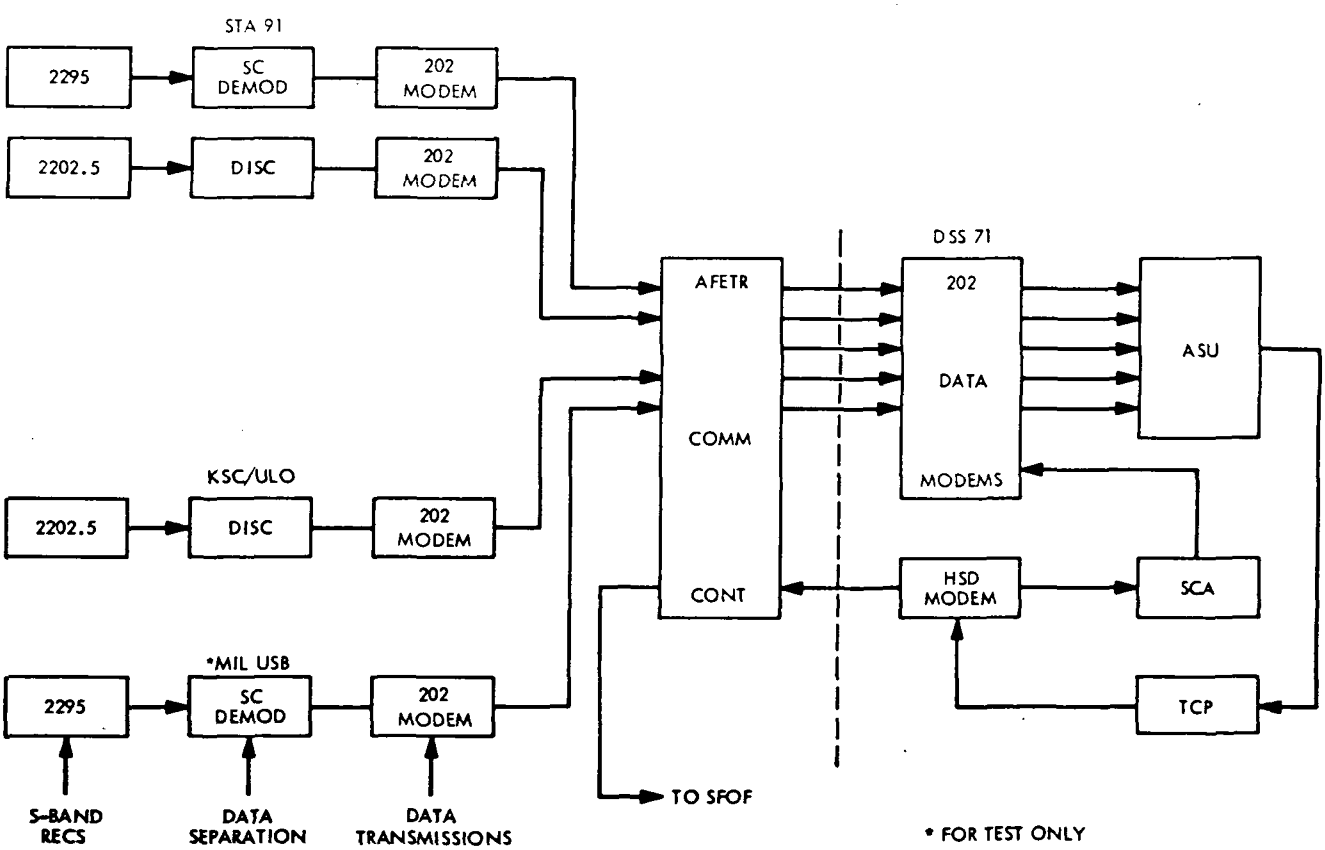


Fig. 19. DSS 71 telemetry data interface diagram (simplified)

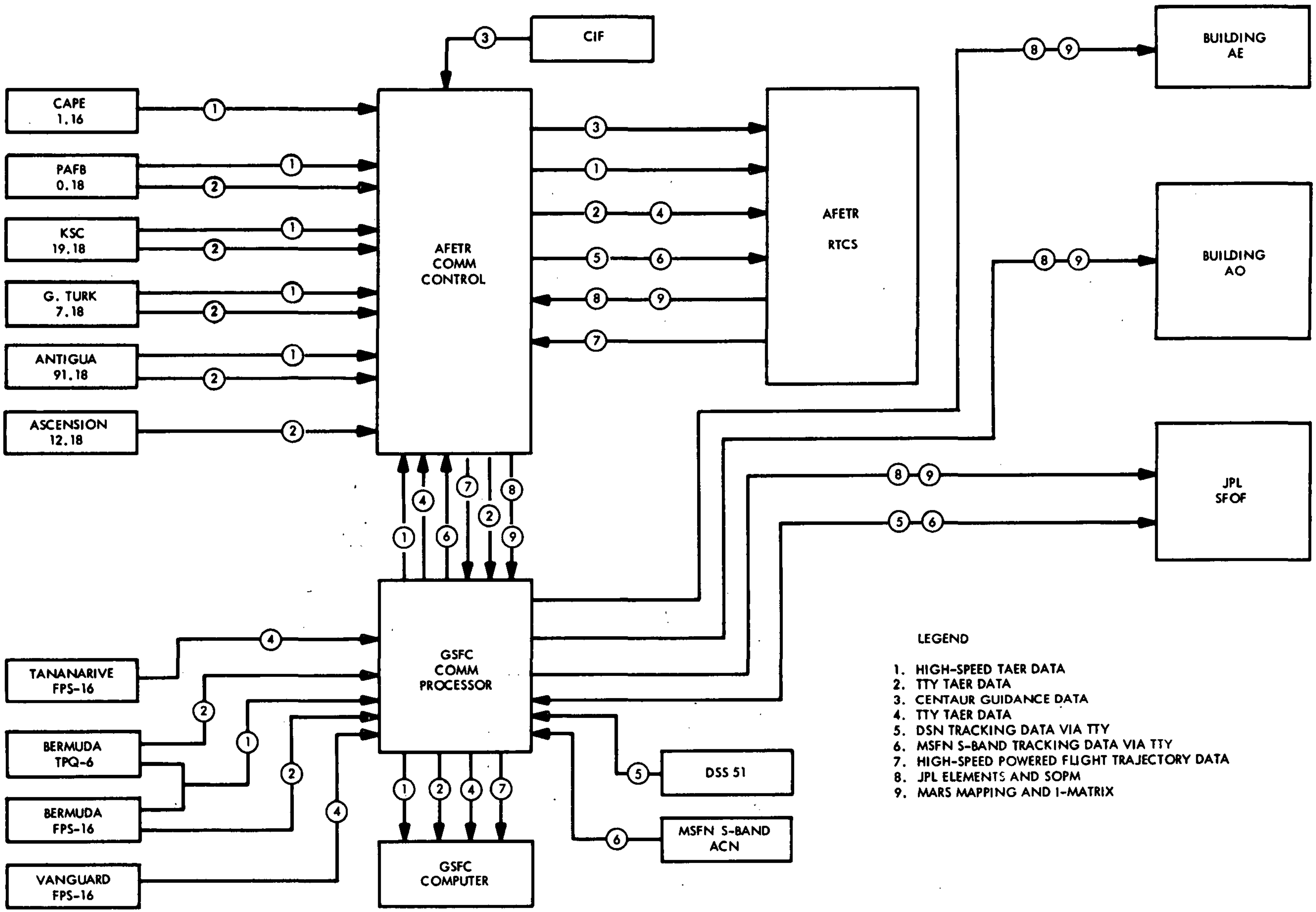


Fig. 20. Near-Earth-phase tracking data flow

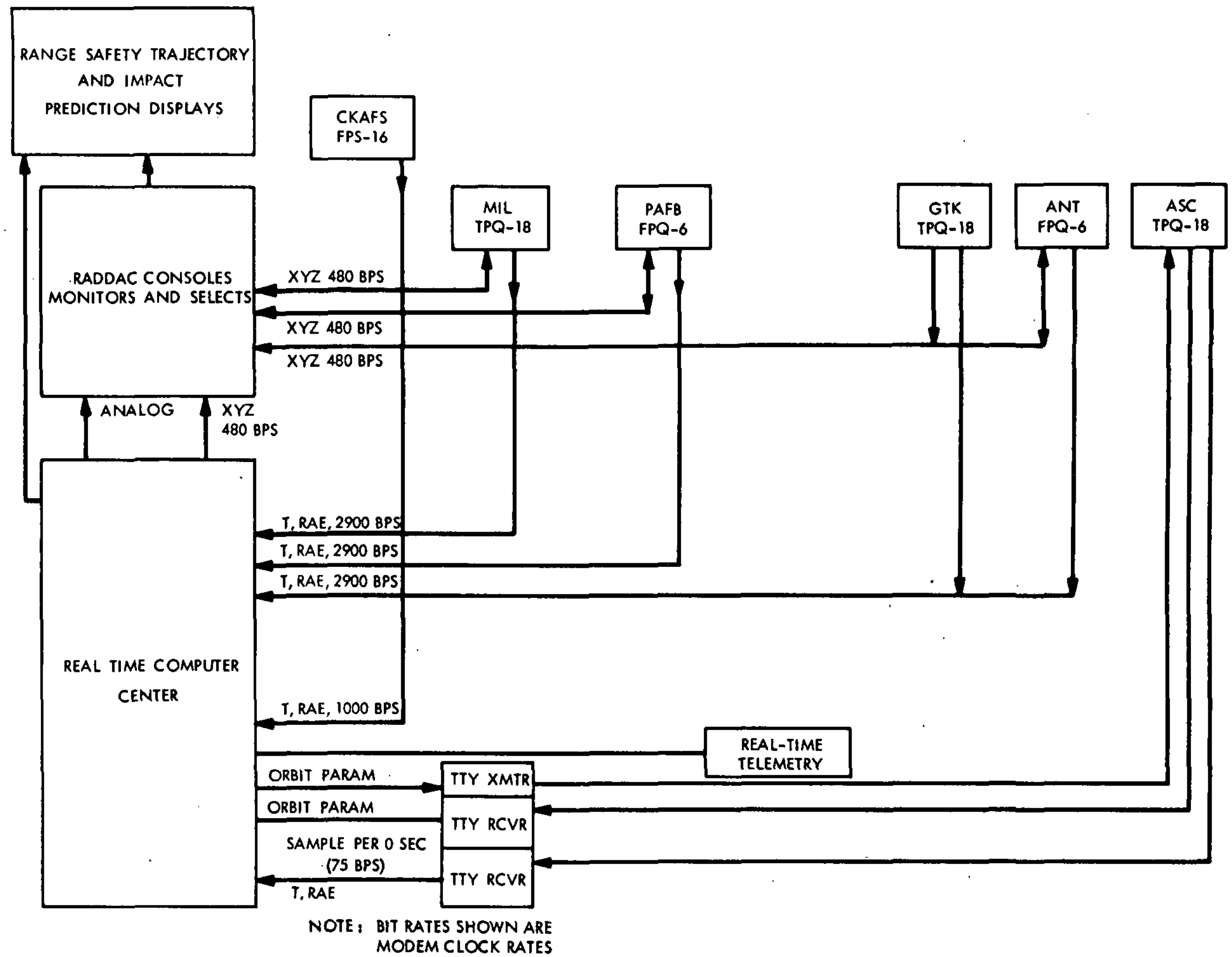


Fig. 21. AFETR tracking data system (simplified)

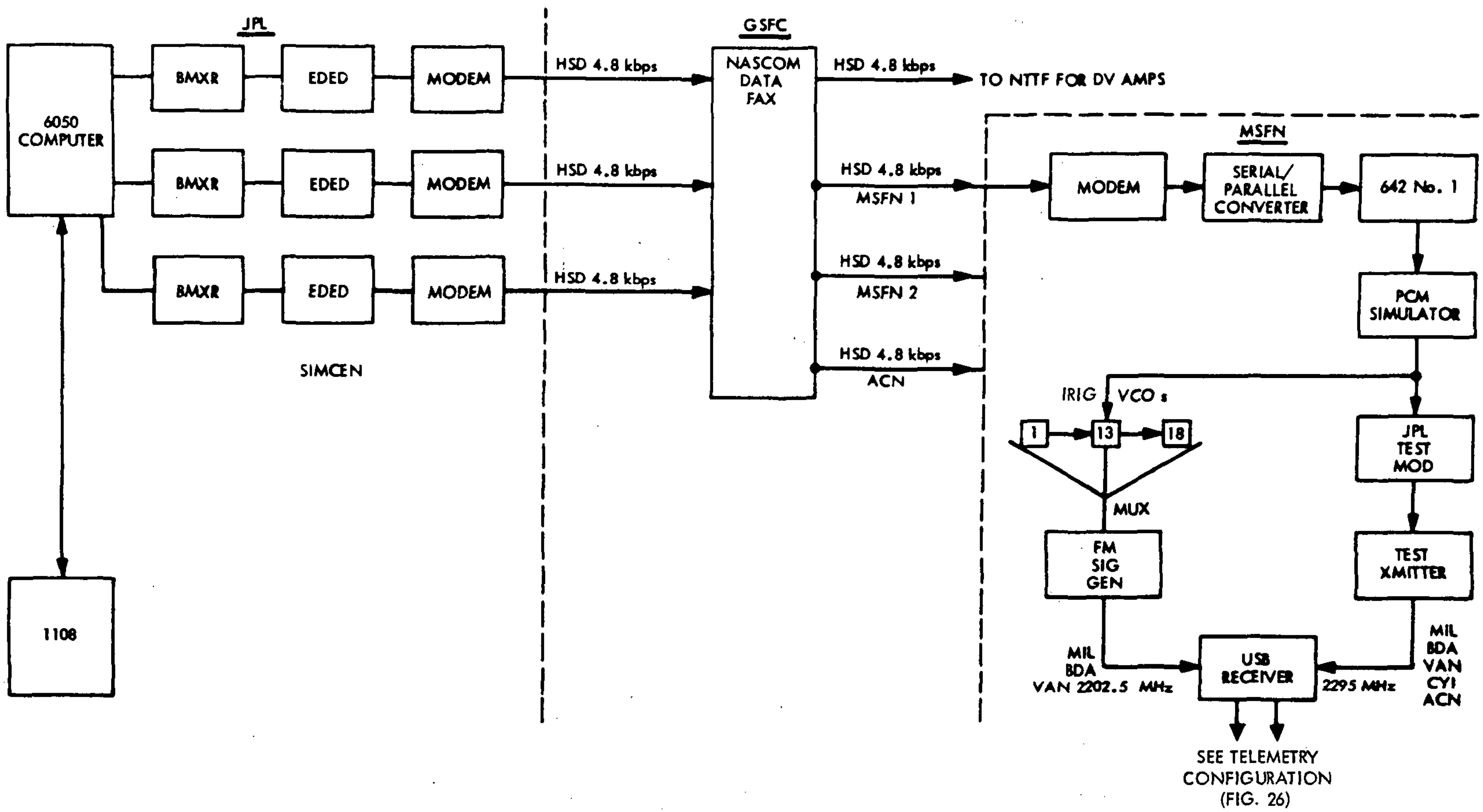


Fig. 22. MSFN configuration for telemetry data simulation diagram (simplified)

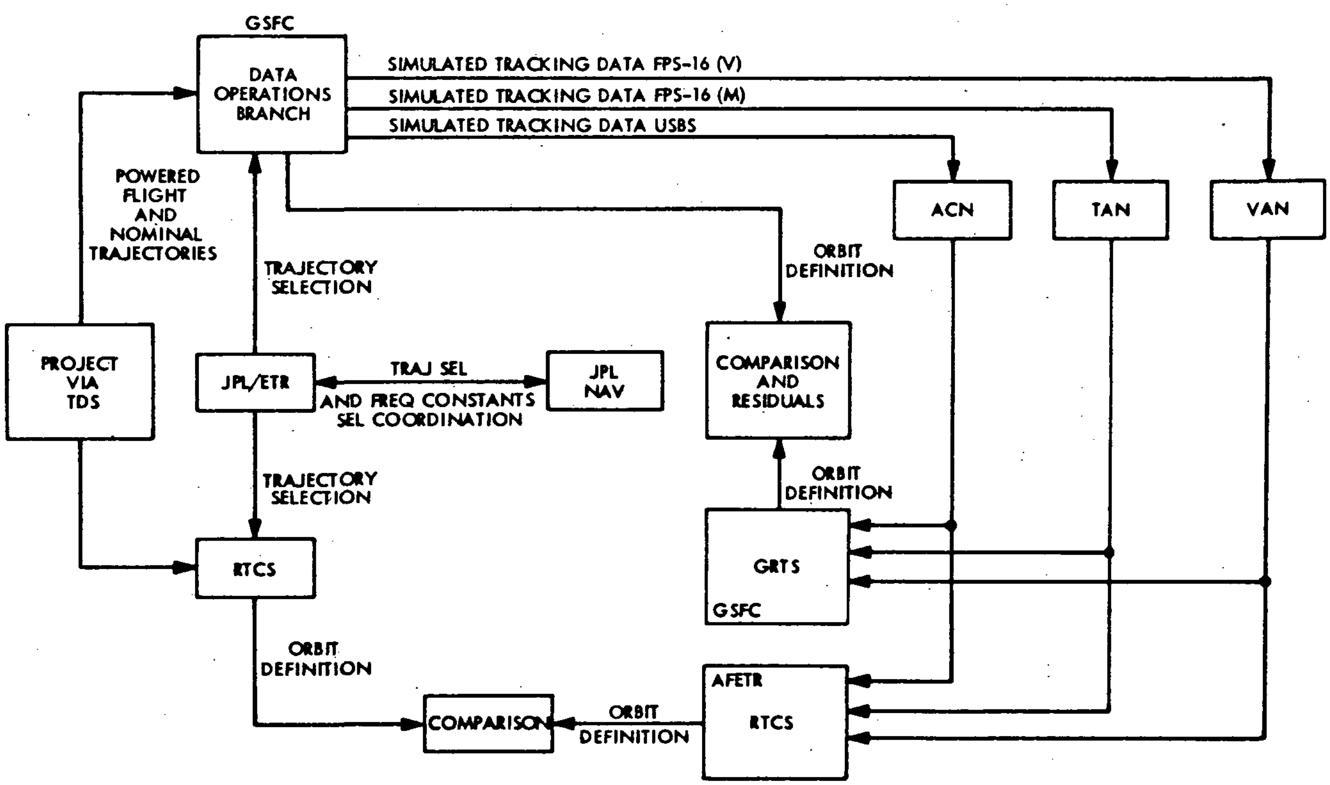


Fig. 23. MSFN tracking data simulation diagram (simplified)

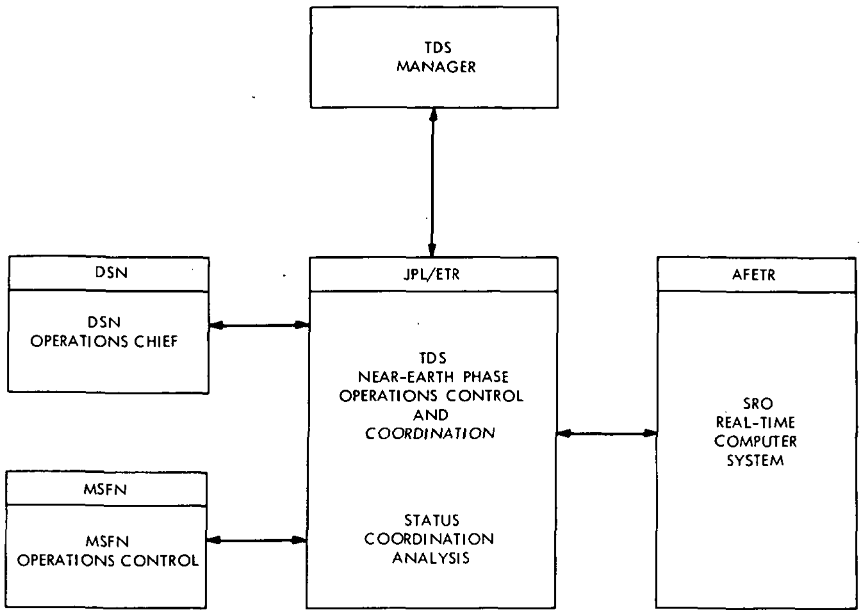


Fig. 24. Operational structure

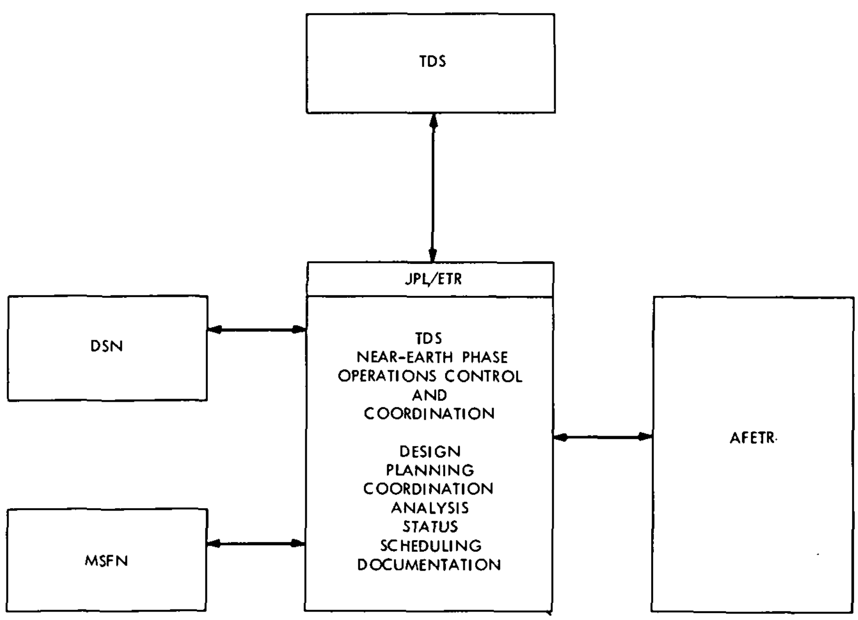


Fig. 25. Nonoperational structure

Page intentionally left blank

Table 21. Footnote key to Fig. 26

FOOTNOTES, TELEMETRY SYSTEM: 26-METER-ANTENNA SUBNET

DATA FLOW PATHS

1. Carrier from spacecraft (S/C) 1
2. Carrier from S/C 2
3. Video (coded at 2.025 kbps or 1.0125 kbps
4. Science (uncoded) at 50 bps
5. Engineering (uncoded) at 33-1/3 or 8-1/3 bps
6. Ground Automatic Gain Control (AGC) (analog)
7. Playback of previously recorded Subcarrier Demodulator Assembly (SDA) outputs
8. Computer to computer outputs of configuration changes, alarms, and Signal-to-Noise Ratio (SNR) (db)
9. Digital recording of all 920 data inputs, one for recording each S/C. ODR for both video and nonvideo data. Also, replay of Original Data Record (ODR)
10. Time for time-tagging data
11. HSD to SFOF:
    a. Engineering data from both S/C
    b. Science from both S/C at 50 bps or science from one S/C at 50 bps and high rate science from the other S/C at 2 kbps (max)
    c. Replay of ODR (not simultaneous with a and b)
    d. DSS Telemetry System partial status: lock status of receiver, SDA, SSA, and Block Decoder, plus time and serial number of the GCF HSD block
    e. Ground AGC and subcarrier SNR in db

Table 21 (contd)

FOOTNOTES, TELEMETRY SYSTEM: 26-METER-ANTENNA SUBNET

(12) TTY to SFOF, decommutated engineering and selected 50 bps science data from both S/C (backup only). TTY science transmission subject to limitations of the 920.

(13) Telemetry Data/Master Data Record (MDR) transfer for Project analysis programs

(14) DSN MDR data (may require subsequent supplementing with ODR)

(15) Time

(16) Telemetry prints and plots, and program/operator interplay

(17) SFOF Telemetry System alarms: periodic status (sync, data output, number of records made, data block errors detected, etc.); data loss alarms (tape, display, to comm, or in certain programs)

(18) S/C AGC and Static Phase Error (SPE) from telemetry data to the Station Monitor and Control subsystem (SMC) via Digital Instrumentation Subsystem (DIS) for Command System - teletype form

(19) Time for time track of recording

(20) Predetection recording - no playback

(21) SDA Output recording

(22) TTY formatted simulated tracking data from three DSS (either S/C from any DSS), plus backup engineering and selected 50 bps science and TTY from three simulated DSS (two S/C per DSS)

(23) Program operator interplay

EQUIPMENT/SUBSYSTEM CAPABILITIES

DSN/MM'71 Telemetry System for 24-Meter-Antenna Subnet

(A) System Temperature: $65^{\circ}K$ or less at 10 deg or more above horizon

(B) Output time accurate to 1 msec

Table 21 (contd)

FOOTNOTES, TELEMETRY SYSTEM: 26-METER-ANTENNA SUBNET

(C) TTY page printers located in DSN Telemetry System Operations area and Mission Support areas (MSA)

(D) Terminal devices located at MSA. See Table 31 and Figures 47-50 for types, quantity, and location.

(E) One full duplex line shared by all systems

SOFTWARE CAPABILITIES

(a) SDS 920 TCP Program Capabilities for Telemetry (see Command System footnote (a) for command capabilities, Figure 31)

A. Input Processing

Input process:

1. High rate science data at 2 kpbs or 1 kbps from decoder or science data at 50 bps from SSA

2. Engineering data at 8-1/3 bps or 33-1/3 bps from SDA

3. Ground AGC via MUX-ADC

4. Time reference for time tagging data

5. Hardware lock status of receiver, SDA, BDA, and SSA

6. Operator messages through the computer console

B. Output Processing

Output process and format:

1. HSD transmissions of the following data:

(a) Engineering data and time tags at 8-1/3 or 33-1/3 bps

(b) Science data and time tags at 1 kbps, 2 kbps, or 50 bps

(c) Computed AGC (db) and subcarriers SNR (db)

(d) Lock status of receiver, SDA, BDA, bit sync, and SSA

Table 21 (contd)

FOOTNOTES, TELEMETRY SYSTEM: 26-METER-ANTENNA SUBNET

2. TTY transmissions of engineering and selected 50 bps science data, lock status indicators and time tags in "readable" decommutated form on one line

3. TTY transmission of S/C AGC and Static Phase Error (SPE) to SMC via DIS

4. Transmission to DIS computer via 24-bit parallel register of the following:

   (a) Configuration changes

   (b) Alarms

   (c) SNR in db

5. Digital magnetic log tape (ODR) containing all inputs received except operator controlled messages

6. Operator messages

C. Internal Processing

1. Perform bit synchronization and detection on engineering data

2. Frame sync engineering and 50 bps science data using generalized frame sync pattern and frame length techniques

3. Decommutate engineering and 50 bps science data using commutation code word in synchronized frame

4. Calculate SNR and AGC in db

b Part I - 360/75 Mission-Independent Software Capabilities

A. Input

1. Input process data simultaneously on up to three HSD and one wideband line. Separate by header information into:

   (a) S/C No. 1 telemetry and partial status data

   (b) S/C No. 2 telemetry and partial status data

Table 21 (contd)

FOOTNOTES, TELEMETRY SYSTEM: 26-METER-ANTENNA SUBNET

2. Make S/C No. 1 data available to mission-dependent processor No. 1 (see Part II of b)
3. Make S/C No. 2 data available to mission-dependent processor No. 2 (see Part II of b)
4. Input process all messages from UT&D SS
5. Input process log tape to allow for replay capability which simulates situation of real-time input of same data
6. Provide for certain input control for system diagnostics and error tracing
7. Input process time

B. Output

Output process and format:

1. Print and plot information to UT&D SS
2. Log tape containing all received high speed and wideband data
3. Real-time telemetry DSN MDR for all telemetry data including video for each S/C
4. SFOF Telemetry System alarms to monitor program (see footnote 17)

C. Internal Processing

1. Calculation of differences between supplied limits and those T/M values to be alarmed
2. Calculation of engineering units from T/M parameters in counts through a polynomial transformation

Table 21 (contd)

FOOTNOTES, TELEMETRY SYSTEM: 26-METER-ANTENNA SUBNET

Part II - 360/75 Mission-Dependent Software Capabilities

1. Frame sync and decommutate T/M from HSD blocks using generalized frame sync methods which allow for control of T/M frame length and sync pattern

2. Format Central Computer and Sequencer (CC&S) dump received via mission-independent system from HSD for MSA

3. Accumulate SFOF partial status: sync lock, system alarms, and HSD and wideband error alarms

4. Extract DSS partial status from data blocks and, together with SFOF partial status, generate DSN MDR according to predetermined algorithm

(b) 1108 Software Capabilities

Totally provided by Project; outside scope of this document.

(c) TCP (920) Playback Program

A. Input Processing

Input process:

1. Console messages specifying data to be replayed

2. Data from digital tape (ODR)

B. Output Processing

Output process and format the requested data in a format identical to output of program (a)

C. Internal Processing

Perform search of data on tape based upon input parameters

(d) 1108 Computer Analysis Software

Supplied by Project.

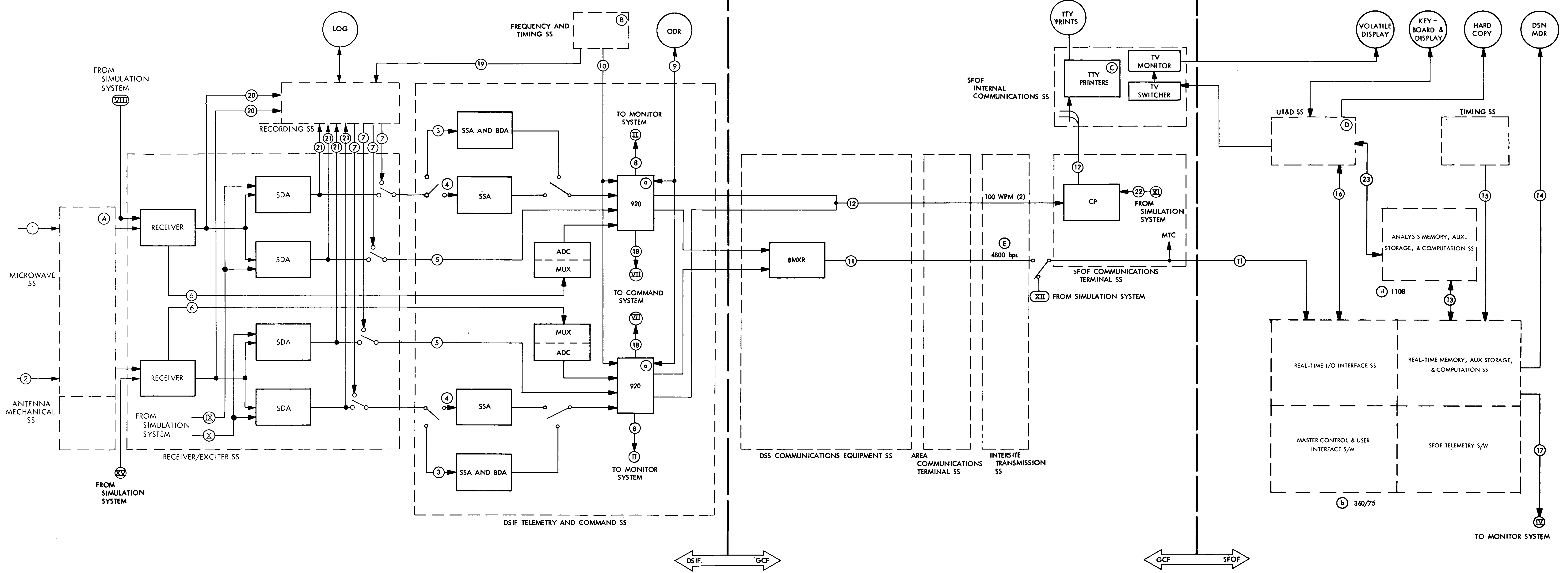


Fig. 26. DSN/MM '71 Telemetry System, 26-m-diameter antenna subnet

Table 22. Footnote key to Fig. 27

TELEMETRY SYSTEM: DSS 14 ORBITAL PHASE*

DATA FLOW PATHS

1. Carrier from S/C 1
2. Carrier from S/C 2
3. Video coded at 16.2, 8.1, 4.05, 2.025, or 1.0125 kbps or uncoded science at 50 bps
4. Engineering uncoded at 33-1/3 or 8-1/3 bps when no hi-rate > 2 kbps is received
5. Engineering uncoded at 33-1/3 or 8-1/3 bps when hi-rate > 2 kbps is received
6. Ground AGC (analog)
7. Playback of previously recorded SDA outputs
8. Computer to computer outputs of configuration changes, alarms, and SNR
9. Digital recordings (3) of all 920 data inputs, one recording for each 920. ODR for video and nonvideo data. Also, replay of ODR.
10. Time for time-tagging data
11. HSD to SFOF, maximum of:
    - a. Engineering data from both S/C
    - b. Science from both S/C at 50 bps; no coded video
    - c. Replay of ODR (not simultaneous with a and b)
    - d. DSS Telemetry System partial status: lock status of receiver, SDA, SSA, and Block Decoder, plus time and serial number of the GCF HSD block
    - e. Ground AGC and subcarriers SNR in db

*Cruise phase or playback of 1 or 2k video is identical with 26-meter-antenna Subnet Telemetry System diagram

Table 22 (contd)

TELEMETRY SYSTEM: DSS 14 ORBITAL PHASE

12 TTY to SFOF, decommutated engineering and selected 50 bps science data from both S/C (backup only). TTY science transmission subject to limitations of the 920.

13 Two high rate telemetry streams (16.2 kbps each max)

14 Telemetry Data/MDR transfer for Project

15 DSN MDR data (may require later supplementing with ODR)

16 Time

17 Telemetry prints and plots and program/operator interplay

18 SFOF Telemetry System Alarms: periodic status (sync, data output, number of records made, data block errors detected, etc.); data loss alarms (tape, display, to comm, or in certain programs)

19 S/C AGC and SPE from telemetry data to SMC via DIS for Command System - teletype form

20 Time from time track of recording

21 Predetection recording - no playback

22 SDA output recording

23 TTY formatted simulated tracking data from three DSS (either S/C from any DSS), plus backup engineering and selected 50 bps science and TTY from three simulated DSS (two spacecraft per DSS)

24 Program operator interplay.

EQUIPMENT/SUBSYSTEM CAPABILITIES

A System Temperature: 40° K or less at 10 deg or more elevation

B Output time accurate to 1 msec

Table 22 (contd)

TELEMETRY SYSTEM: DSS 14 ORBITAL PHASE

(C) TTY page printers located in DSN Telemetry System Operations area and MSA

(D) Located at MSA

(E) One full duplex line shared by all systems

SOFTWARE CAPABILITIES

SDS 920 Telemetry and Command Processing Program Capabilities

Three separate programs will exist at DSS 14 for use with various data stream combinations from one or two spacecraft. These programs will operate in one, two, or three 920 computers, as required. These are programs (a), (d), and (e) described on the following pages.

(a) STANDARD 26-METER-ANTENNA TCP PROGRAM

This is the same TCP 920 program described for the 26-meter antenna subnet. The program can only be used whenever either S/C is transmitting noncoded data only or transmitting uncoded engineering and coded science data at the 2 kbps or 1 kbbs. Also, with the engineering and command processing disabled, this TCP 920 program processes 4, 8, and 16 kbps high-rate data.

(b) PART I - 360/75 MISSION-INDEPENDENT SOFTWARE CAPABILITIES

The 360/75 mission-independent software capabilities are identical to those described in the software notes for DSN/MM'71 Telemetry System for the 26-meter subnet (Figure 26), except for the additional capability to process two high rate streams from the GCF wideband line.

(c) PART II - MISSION-DEPENDENT CAPABILITIES IN THE 360/75

The capabilities of this processor are the same as those described in the software notes for Figure 26, DSN/MM'71 Telemetry System for the 26-meter subnet.

Table 22 (contd)

TELEMETRY SYSTEM: DSS 14 ORBITAL PHASE

(c) SOFTWARE CAPABILITIES OF 1108 COMPUTER

Totally provided by Project; outside the scope of this document.

(d) TCP (920) PLAYBACK PROGRAM

This is the same program described in the software footnotes for Figure 26, DSN/MM'71 Telemetry System for the 26-Meter Subnet.

(e) TCP: DUAL ENGINEERING TELEMETRY PROGRAM

This program will service one or two engineering telemetry data streams and will provide command capability for one S/C.

A. Input Processing

Input process:

1. Engineering data at 8-1/3 or 33-1/3 bps for one S/C direct from SDA
2. Engineering data at 8-1/3 or 33-1/3 bps for other spacecraft from SSA
3. Ground AGC via MUX-ADC for one or two S/C
4. Time for time-tagging data
5. Equipment status for receivers, SDAs, and SSA
6. Operator messages

B. Output Processing

Output process and format:

1. HSD transmissions of the following:
   (a) Engineering data, lock status, and time tags for one or two S/C at 8-1/3 or 33-1/3 bps
   (b) Ground AGC (db) and time tags for one or two S/C
   (c) SNR for engineering subcarrier

Table 22 (contd)

TELEMETRY SYSTEM: DSS 14 ORBITAL PHASE

2. TTY transmission of one or both engineering streams with time tags on one of two TTY lines

3. S/C AGC and SPE for TTY transmission to SMC for one or two S/C

4. Transmission to the DIS computer via 24-bit parallel register of the following:

   (a) Configuration changes
   (b) Alarms
   (c) SNR in db

5. A digital magnetic log tape (ODR) containing all inputs except operator messages

C. Internal Processing

1. Perform bit synchronization and detection on engineering data (8-1/3 or 33-1/3 bps) direct from SDA

2. Frame sync one or two engineering data streams by generalized frame sync pattern and frame length techniques

3. Decommutation of one or two engineering telemetry data streams by commutation code word in synchronized frame

4. Calculate SNR and AGC in db

f 1108 Computer Analysis Software

Supplied by Project.

Fig. 27. DSN/MM '71 Telemetry System, DSS 14

Table 23. Footnote key to Fig. 28

DSN/MM'71 TRACKING SYSTEM: 26-METER-ANTENNA SUBNET

DATA FLOW PATHS

1. S-band downlink from one spacecraft
2. Amplified, modulated S-band carrier (one spacecraft at a time)
3. Transmitter drive, modulated with ranging signals (one spacecraft at a time) when required
4. Autotrack feedback
5. Reference frequency
6. Time
7. Time for time-tagging data
8. Punched paper tape output of TDH, with readback capability (TDH not required for readback)
9. Range data from one of the two spacecraft
10. Exciter or receiver reference frequency, analog
11. Doppler from one of the two spacecraft
12. Actual antenna pointing angles
13. Exciter frequency, doppler, angles, and ranging (digital form)
14. TTY formatted metric data including DSS Tracking System partial status via TDH paper tape punch
15. Metric data to 1108 for orbit determination and other processing
16. Time
17. Processed tracking data prints, pseudoresidual and other tracking data plots, and program/operator interplay

Table 23 (contd)

DSN/MM'71 TRACKING SYSTEM: 26-METER-ANTENNA SUBNET

18 Program/operator interplay

19 Not used

20 DSN MDR, digital tape form

21 Validated spacecraft ephemeris data to 360/75

22 SFOF Tracking System alarms

23 Predicts to DSS, backup to 24

24 Predicts, transmitted over HSD via DSN Operations Control System, including open loop receiver predicts for DSS 41 and 62

25 Standards and limits, transmitted prepass over HSD

26 Predicts, page print form

27 Predicts, paper tape form

28 Predicts, paper tape form

29 Predicts, magnetic tape form

30 Angle difference (digital), between predicted and actual

31 DSS detected alarms

32 Antenna drive signals

33 Occultation experiment support equipment output signals for analog recording

34 Analog recordings of occultation data via mail

EQUIPMENT/SUBSYSTEM CAPABILITIES

A Output, 10 kw

B Time accuracy, 20 μsec

C Lunar distance ranging only, for one spacecraft

D Located at MSA

Table 23 (contd)

DSN/MM'71 TRACKING SYSTEM: 26-METER-ANTENNA SUBNET

E Located in DSS operational area

F Function physically performed in monitor computer

G Function physically performed in monitor computer

H DSS 41 and 62 each have one open-loop receiver and other occultation experiment support equipment in addition to the normal complement of equipment

I One full duplex line shared by all systems

SOFTWARE CAPABILITIES

a Mission-Independent Software Capabilities, 360/75

The system provides the same input and output capabilities as those for telemetry (Figure 26).

In addition, the system provides capabilities for the tracking data system:

A. Input Processing

Input process:

1. Messages for controlling the printing and/or plotting of pseudoresiduals
2. Formats to be used to identify and extract the metric data in TTY messages
3. Validated S/C ephemeris data to be used in calculating tracking predictions and pseudoresiduals direct from 1108 or from tape
4. TTY metric data received via CP interface
5. Control information for transmitting tracking predictions
6. Control messages for operating the Tracking Data Processor (TDP)

Table 23 (contd)

DSN/MM'71 TRACKING SYSTEM: 26-METER-ANTENNA SUBNET

B. Output Processing

Output process:

1. Error or acceptance messages to operators
2. Pseudoresiduals to UT&D SS
3. TTY metric data to the log tape and 1108
4. Prediction data for transmission via CP or HSD
5. SFOF Tracking System alarm messages to the monitor program
6. TDP generated displays

C. Internal Processing

1. Pseudoresidual processing

   a. Generate predicted tracking data from validated S/C ephemeris data

   b. Subtract actual tracking data from predicted tracking data on a point-by-point basis to create psuedoresiduals. Check S/C number, station, time, and data type before pseudoresidual is created. If the actual tracking data point has no corresponding time point in the predicted tracking data, use a Lagrangean polynomial interpolation method to obtain a corresponding predicted tracking data point at the same time as the tracking data point.

   c. If the pseudoresidual is out of the given plot limits, then the appropriate (high or low) designator (H or L) is given to the value and plotted at the appropriate limit.

   d. Accept tracking predictions and, under input control, format for either TTY transmission through CP interface, or for HSD transmission.

Table 23 (contd)

DSN/MM'71 TRACKING SYSTEM: 26-METER-ANTENNA SUBNET

2. Tracking Data Processor. TDP performs the basic task of accumulating all recognizable tracking data into an SDR. The program performs format and other validity checks, and generates summary prints and detail prints. This program puts the tracking data SDR onto magnetic tape and transmits its output directly to the 1108 upon request.
3. Prediction Program. PRDX computes and outputs S/C position, doppler, topocentric angle, range, and best-lock frequency for each DSS view period. Output may be transmitted over HSD or TTY. Preflight nominal predicts may be output on microfilm.
4. Tracking System Analytical Calibration (TSAC) Program. TSAC computes calibration coefficients for correcting doppler data to compensate for charged particle effects along the ray path using Differenced Range Vs Integrated Doppler (DRVID) data. DRVID also computes calibration coefficients for the troposphere, based on an atmospheric model or ground-weather data measurements.

b Software Capabilities of 1108 Computer

Totally provided by Project; outside the scope of this document

c Not used

d Antenna Pointing Program (APS). The 920 APS program accepts either Inter-Range Vector (IRV) input via punch paper tape or console, or a punched paper tape of angle and time. The program will generate angle and time data given in IRV. Angle and time data, either given to or generated by the program, are used to control the antenna through the antenna mechanical subsystem.

e Phase II Monitor (DIS). This program accepts exciter frequency, doppler, range and angles from TDH-1, and angle errors from antenna pointing. These data are compared to onsite tracking data predictions, and pseudoresiduals are generated and displayed in printed form. See Figure 34 for a complete description.

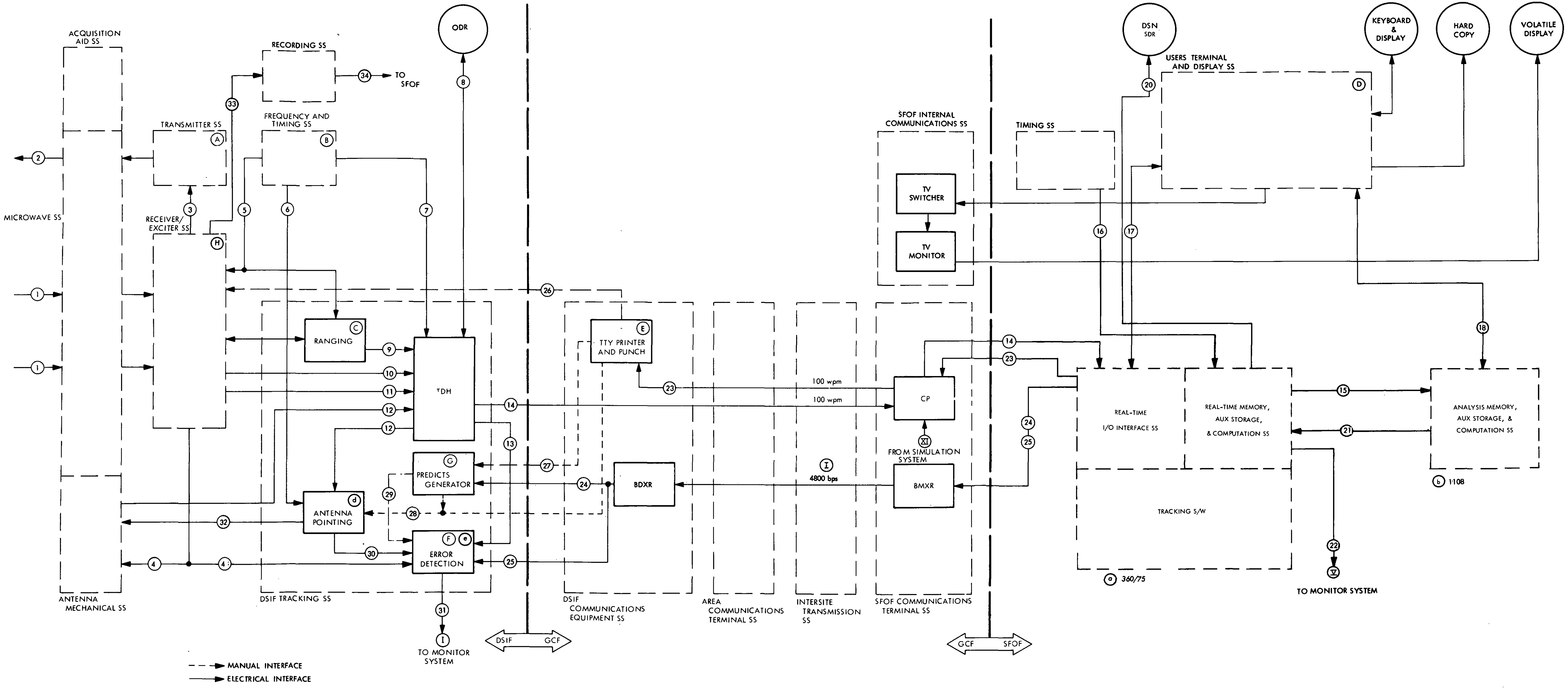


Fig. 28. DSN/MM '71 Tracking System, 26-m-diameter antenna subnet

Page intentionally left blank

Table 24. Footnote key to Fig. 29

TRACKING SYSTEM: DSS 14

DATA FLOW PATHS

1 - 32 Same as 26-meter-antenna network except autotrack feedback 4 not used.

Note switchable doppler extractor output on diagram. Allows rapid selection of doppler data from either of two simultaneous two-way links.

33 Occultation experiment support equipment output signals for digital recording

34 Digital recordings of occultation data via mail or expedited delivery

EQUIPMENT/SUBSYSTEM CAPABILITIES

A 1. Power amplifier with backup generator for primary power provides 20 kw S-band power transmitted to one spacecraft

2. Using R&D equipment, a 400 kw power amplifier without backup generator for primary power provides the following:

RF power, about 40 kw for each of two S-band signals transmitted simultaneously to two spacecraft

or

S-band power, about 400 kw transmitted to one spacecraft

B Time accuracy, 20 μsec

C Planetary ranging, one S/C (R&D equipment)

Table 24 (contd)

TRACKING SYSTEM: DSS 14

D Located at MSA

E Located in DSS operational area

F Function physically performed in monitor computer

G Function physically performed in monitor computer, prepass

H Open-loop receiver and other occultation experiment support equipment, including data digitizer, in addition to normal complement of equipment

I Includes special digital recorder

J One full duplex line shared by all systems

SOFTWARE CAPABILITIES

a - e Same as for 26-meter-antenna subnet

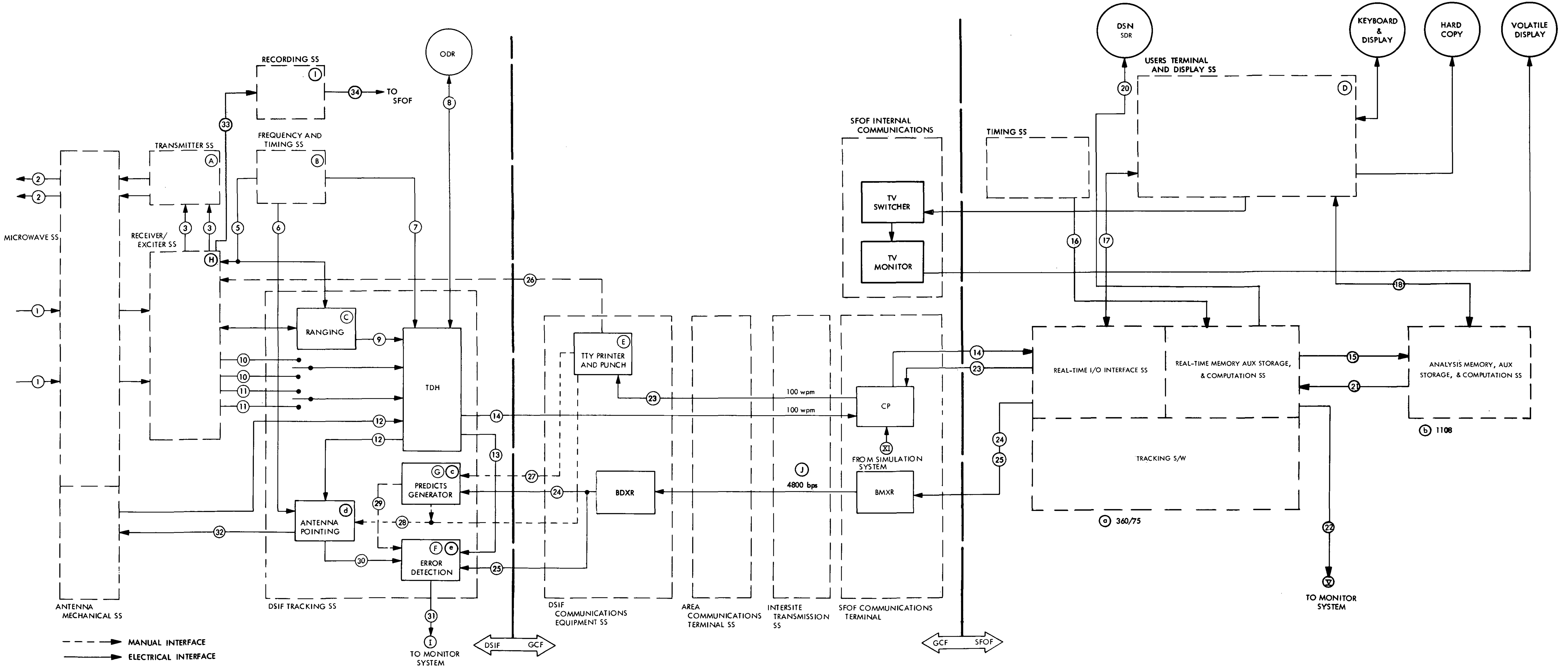


Fig. 29. DSN/MM '71 Tracking System, DSS 14

Table 25. Footnote key to Fig. 30

TRACKING SYSTEM: DSS 14 ENGINEERING ALTERNATE

DATA FLOW PATHS

1	S-band downlink from one spacecraft
2	Amplified, modulated S-band carrier
3	Transmitter drive, modulated with ranging signals when required. Range modulation of only one carrier at a time is permitted.
4	Reference frequency
5	Time
6	Range data for one of the two spacecraft
7	Doppler from each spacecraft
8	Exciter frequency (analog) for each spacecraft
9	Actual antenna pointing angles
10	Digital magnetic tape recording of all data output for both spacecraft, including 1/10 second doppler samples during occultation periods, with postpass readback capability
11	TTY formatted and batched tracking data including DSS Tracking System partial status for both spacecraft-backup to 12
12	High speed tracking data for two spacecraft, including DSS Tracking System partial status, transmitted over HSD
13	All tracking data to 1108 for orbit determination and other processing
14	Time
15	Processed tracking data prints, pseudoresidual and other tracking data plots a program/operator interplay
16	TDP master file, digital tape form, DSN MDR

Table 25 (contd)

TRACKING SYSTEM: DSS 14 ENGINEERING ALTERNATE

17 Program/operator interplay

18 Not used

19 Validated spacecraft ephemeris data to 360/75

20 Tracking System alarms

21 Predicts to DSS (backup, to 22)

22 Predicts for two spacecraft, transmitted prepass over HSD. Includes open-loop receiver predicts.

23 Standards and limits, transmitted prepass over HSD

24 Predicts, page print form (exciter frequency for each of two spacecraft)

25 Antenna drive signals

26 DSS detected alarms

27 Occultation experiment support equipment output signals for digital recording

28 Digital recordings of occultation data via mail or expedited delivery

EQUIPMENT/SUBSYSTEM CAPABILITIES

A , B Same as for standard DSS 14 Tracking System

C A single multipurpose computer which performs the following functions:

Tracking Data Formatting
Planetary Ranging
Error Detection
Predict Processing
Antenna Pointing

Table 25 (contd)

TRACKING SYSTEM: DSS 14 ENGINEERING ALTERNATE

D Located at MSA

E Same as for 26-meter-antenna subnet

F Open loop receiver and other occultation experiment support equipment, including data digitizer, in addition to normal complement of equipment

G Includes special digital recorder

H One full duplex line shared by all systems

SOFTWARE CAPABILITIES

a Mission-Independent Software Capabilities of 360/75

The system provides the same I/O capabilities as those provided for the 26-meter-antenna tracking subnet interface. In addition, the capability exists for input processing of tracking data via HSD from the computer based DSIF Tracking Subsystem (DTSS) at DSS 14. Once the input of this high-speed tracking data has been accomplished, internal processing must be completed to make the data appear the same as tracking data received via the CP interface. The data are then usable with the tracking predictions, pseudoresidual capabilities, and all other capabilities described under output processing and internal processing sections of the 26-meter-antenna subnet tracking system software footnotes.

b This capability is independent of whether the SFOF is interfacing with a 26-meter-antenna station or DSS 14.

c A combination of the functions of the TDH and c , d , and e as described for the 26-meter-antenna tracking subnet, with the additional capability of performing c simultaneously with the other functions.

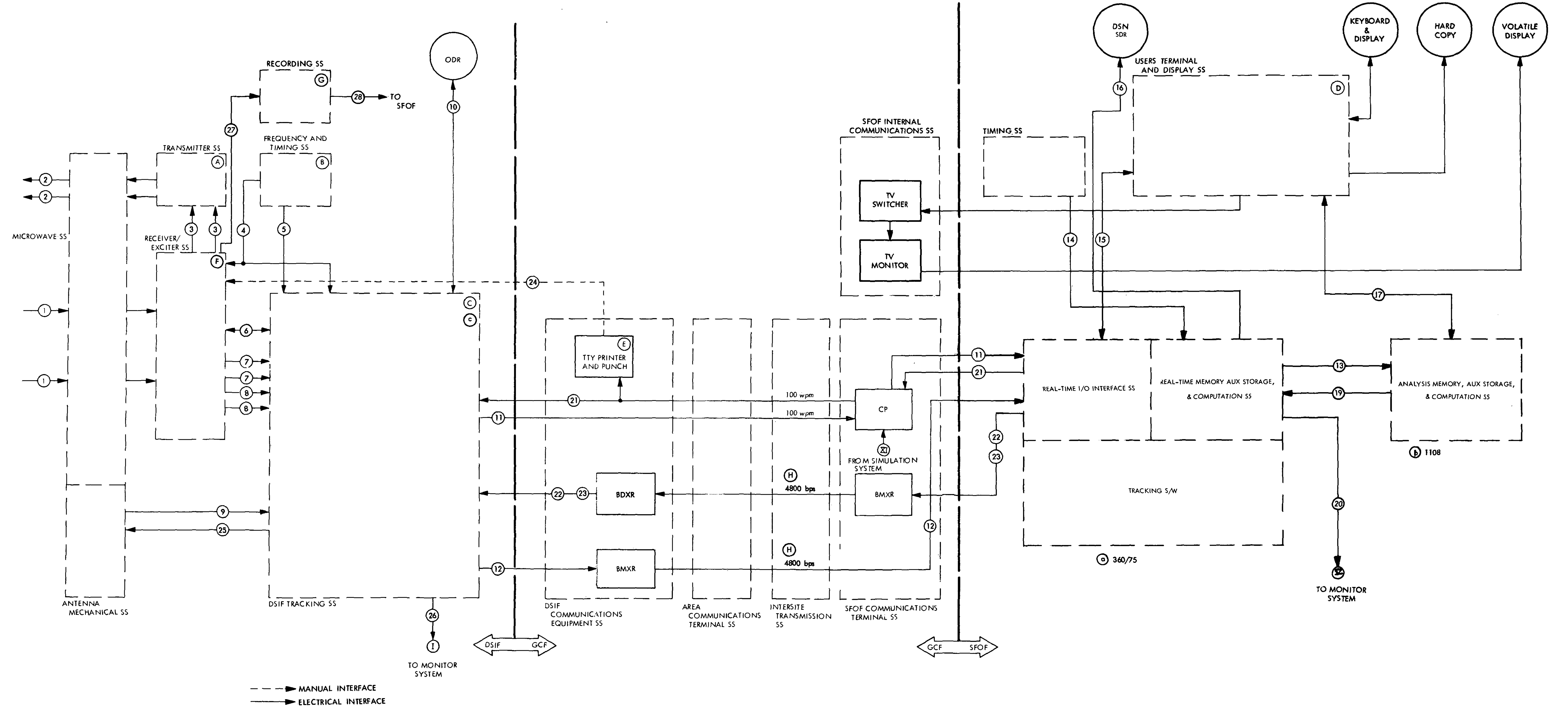


Fig. 30. DSN/MM '71 Tracking System, DSS 14 engineering alternate

Page intentionally left blank

Table 26. Footnote key to Fig. 31

COMMAND SYSTEM: 26-METER ANTENNA SUBNET

DATA FLOW PATHS

1	Amplified, modulated S-band carrier (one S/C at a time)
2	Transmitter drive (one S/C at a time)
3	Command modulated subcarrier (one S/C at a time)
4	For DSS manual entry of commands, 920 keyboard
5	SFOF- or DSIF-generated command bits (one S/C at a time)
6	Command message ENABLE/DISABLE command instructions (for either S/C) and recall requests
7	Command message and instruction verification, command confirmation, abort, and alarms. Replies to queries.
8	Time
9	DSS manual mode control and displays
10	Voice or TTY circuit for backup command transmission coordination
11	DSS local display of commands, verification and confirmation/abort
12	Computer/operator interplay for control of command generation and input of standards and limits, plus command system status
13	Time
14	Commands generated by 1108 COMGEN and SCISIM programs via tape or electrical interface
15	Command System alarms for visual display
16	Confirmation, verification, and other data alarms
17	S/C AGC, SPE, and S/C command lock from telemetry data required to verify command readiness
18	Controls, status, and command bits for closed-loop comparison

Table 26 (contd)

COMMAND SYSTEM: 26-METER ANTENNA SUBNET

19 Reference signal, 1 MHz

20 Not used

21 Not used

22 Confirmation or automatic abort

23 Transmitter status, exciter status, modulation status. PN sync assembly on/off.

24 Modulator output command confirmation

EQUIPMENT/SUBSYSTEM CAPABILITIES

A Power, 10 kw

B Either of two 920 computers implemented with command interface hardware

C Located at SMC

D Located at MSA and Command System Operations Analysis Group

E One full duplex line shared by all systems

SOFTWARE CAPABILITIES

a SDS 920 TCP Program Capabilities for Command (all new capabilities for MM'71

These functions shall be available for one S/C with Telemetry System TCP programs a for 26-meter-antennas (Figure 26), and e for DSS 14 (Figure 27).

Table 26 (contd)

COMMAND SYSTEM: 26-METER ANTENNA SUBNET

A. Input Processing

Input process:

1. HSD command messages and ENABLE/DISABLE messages from SFOF
2. Command messages and ENABLE/DISABLE messages via local DSS input (backup)
3. Status and configuration of multimission command hardware
4. Command System recall requests via either HSD or operator message input
5. Command confirmation bits from command waveform generator and mode control for bit-by-bit comparison
6. Time
7. DSS command instructions from SFOF via HSD

B. Output Processing

Output process and format:

1. The following data for HSD transmission (and TTY transmission as a backup):
   a) Command VERIFY messages
   b) RECALL RESPONSE messages
   c) Command CONFIRMATION/ABORT messages
   d) ALARM messages

Table 26 (contd)

COMMAND SYSTEM: 26-METER ANTENNA SUBNET

2. The following data for transmission to DIS computer via 24-bit parallel register:
    a) Hardware status information
    b) Command System HSD error information
3. Teletype messages to SMC containing such information as:
    a) Indication of command message or ENABLE/DISABLE received
    b) Indication of Command System RECALL REQUEST received and RECALL RESPONSE message
    c) Indication of error in transmission of command
    d) Indication of correct transmission of command (confirmation message)
    e) Indication of command verification message sent
4. Digital magnetic log tape (ODR) containing all command traffic. (Data combined on tape with similar telemetry data ODR.)
5. Command bits to command waveform generator and mode control

C. Internal Processing

1. Initialize multimission command hardware based upon HSD message
2. Keep time against computer clock reference until stored command is to be processed to command waveform generator and mode control hardware
3. Prepare RECALL RESPONSE message

Table 26 (contd)

COMMAND SYSTEM: 26-METER ANTENNA SUBNET

4. Prepare verification message when error-free command message received over HSD

5. Compare command data and messages with standards and limits, and generate alarms if out of tolerance

6. If a command is DISABLED, remove it from storage or, if in process, inhibit transmission of remaining bits

b Software Capabilities of 360/75

The system provides the same input and output capabilities as are provided for telemetry, and are described in the footnotes for the Telemetry System.

An additional capability should exist to input process command messages in the correct format to be processed onto an outbound HSD from magnetic tape or direct electrical interface with the 1108.

A. Internal Processing (new capabilities for MM'71)

1. Command messages are accepted and prepared for HSD transmission

2. Transmit stored command messages to DSS in time sequence, such that the storage capacity of DSS Command System is not exceeded

3. Recall response messages contained in HSD blocks from DSSs are examined, and parameters are extracted to be used in print formats

4. Process verification message received on HSD from DSS to assure correct receipt by DSS. Prepare verification status message for display to Project, or automatically issue an ENABLE message/command retransmission

Table 26 (contd)

COMMAND SYSTEM: 26-METER ANTENNA SUBNET

5. Accept project generated ENABLE/DISABLE message and transmit to DSS
6. Recall request query messages are accepted and prepared for transmission or result in 360/75 command message buffer interrogation and formulation for query reply printout
7. Compare command message parameters with predetermined standards and limits
8. Maintain a message (command) accountability system consistent and compatible with DSS and Project systems
9. Produce the Command MDR
10. Accept CONFIRM/ABORT HSD blocks form DSSs, and display to Project

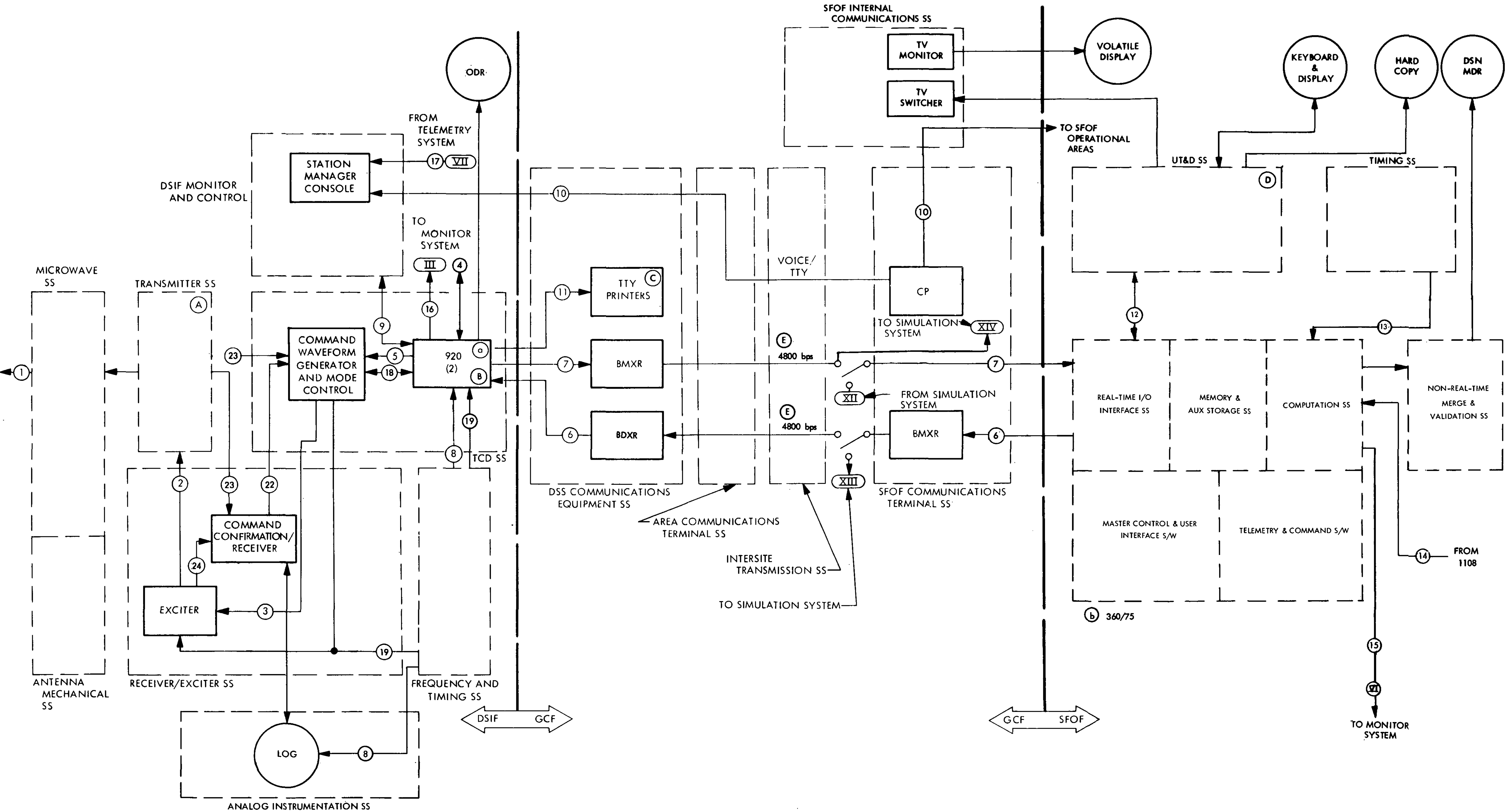


Fig. 31. DSN/MM '71 Command System, 26-m-diameter antenna subnet

Table 27. Footnote key to Fig. 32

COMMAND SYSTEM: DSS 14

DATA FLOW PATHS

1 - 24 Same as for Command System 26-meter-antenna subnet (see Footnotes for Figure 31)

EQUIPMENT/SUBSYSTEM CAPABILITIES

A
1. Power amplifier with backup generator for primary power provides 20 kw S-band power transmitted to one spacecraft
2. Using R&D equipment, a 400 kw power amplifier without backup generator for primary power provides the following:

RF power, about 40 kw for each of two S-band signals transmitted simultaneously to two spacecraft

or

S-band power, about 400 kw transmitted to one spacecraft

B Any two of the three 920s which are implemented with command interface hardware

C Located at SMC

SOFTWARE CAPABILITIES

a Same as for Command System 26-meter-antenna subnet TCP program

b Same as for 26-meter-antenna subnet

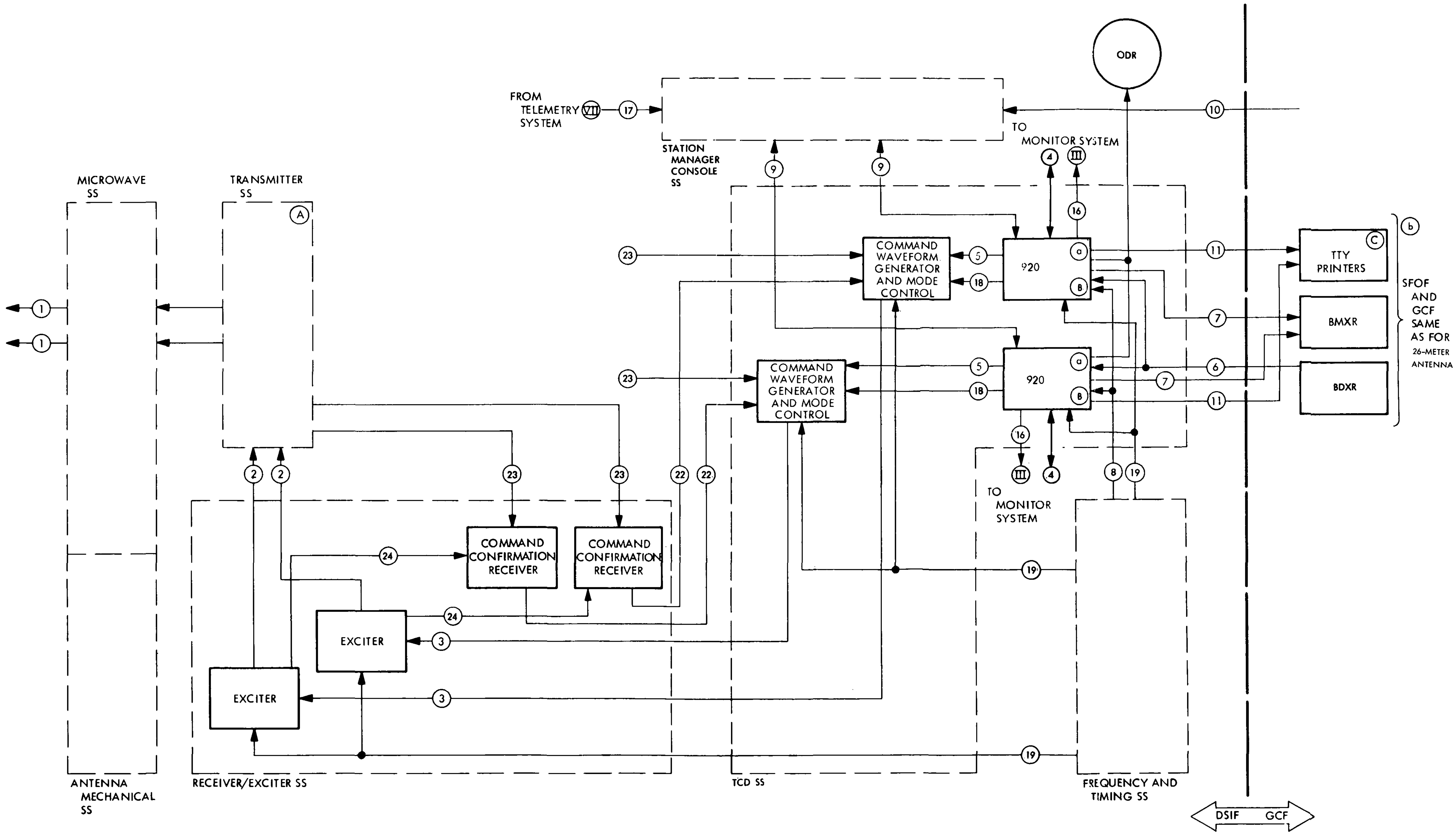


Fig. 32. DSN/MM '71 Command System, DSS 14

Page intentionally left blank

Table 28. Footnote key to Fig. 33

SIMULATION SYSTEM: ALL STATIONS

DATA FLOW PATHS

(1) Simulated data, formatted for HSD transmission to one DSS, in maximum case consisting of:

a. Two engineering streams (8-1/3 bps or 33-1/3 bps)

b. Two 50 bps science streams or, one 50 bps science stream and one high rate science stream (1 kbps or 2 kbps)

c. Bit rate, subcarrier frequency, attenuation and modulation index control information

d. Simulation instructions

e. Simulated commands and standards and limits, if 6050 acting as SFOF

Note: Duplicated for two other DSS

(2) Simulated data, formatted for HSD transmission, simulating output of one DSS, in maximum case consisting of:

a. Two engineering streams (8-1/3 bps or 33-1/3 bps)

b. Two 50 bps science streams or, one 50-bps science stream and one high rate science stream (1 kbps or 2 kbps)

c. Monitor data

d. Command traffic

e. Partial status and supplemental data

f. DTS high speed tracking data (DSS 14 simulation only)

Note: Duplicated for two other DSS (except f.)

Table 28 (contd)

SIMULATION SYSTEM: ALL STATIONS

3	Simulated high-rate data, formatted for wideband transmission, consisting of one 16-kbps (max) high rate stream when transmitted to DSS 14, or two (max) 16 kbps (max) high-rate streams when short-looped direct to MTC and/or 360/75 Note: Two streams to DSS 14 will be attempted, but depend on SCA capability.
4	TTY formatted simulated metric data from three DSS (either spacecraft from any DSS), plus backup engineering and selected 50 bps science TTY from three simulated DSS (two spacecraft per DSS)
5	Command and standard and limits traffic from SFOF when System is simulating DSS Note: Duplicated for two other DSS
6	Command and monitor traffic from DSS, parallel routed to 6050. Other traffic on HSD not used. Note: Duplicated for two other DSS
7	Voice traffic for test coordination and simulation of various operating positions.
8	Data transfer from 1108 math models to 6050, and control information in both directions
9	Processing control information
10	Selected data and system status
11	One engineering bit stream, 8-1/3 or 33-1/3 bps
12	One science bit (symbol) stream, 50 bps uncoded or coded 1 kbps or 16 kbps
13	Mixing ratio (modulation index) control

Table 28 (contd)

SIMULATION SYSTEM: ALL STATIONS

14 S-band attenuator control

15 S-band equivalent of one spacecraft downlink

16 Binary-coded decimal (BCD) time code for use throughout DSS

17 Simulation instructions and SCA control

18 Simulated or real commands to TCP, and nonsimulated traffic of other systems

19 Interval timing interrupt and simulated GMT

20 High-rate data for two spacecraft

EQUIPMENT/SUBSYSTEM CAPABILITIES

A One full duplex line shared by all systems

SOFTWARE CAPABILITIES

a DSS SCA 910 Real-Time Program

A. Input Processing

1. Input process message blocks from one HSD line, with contents listed in note 1

2. At DSS 14, in addition to 1 above, process message blocks from one wideband line, with contents listed in note 3

B. Output Processing

1. Output process four data channels, two engineering (note 11) and two science (note 12)

2. Output process bit rate control, subcarrier frequency control, modulation index control, and attenuation control

b DSS SCA 910 Data Generation Program

A. Input Processing

Input process operator controls and initialization

Table 28 (contd)

SIMULATION SYSTEM: ALL STATIONS

B. Internal Processing

Generate two engineering (8-1/3 or 33-1/3 bps) streams and two science streams (50 bps, 1k, 2k, 4k, 8k, or 16 kbps) in MM'71 format, according to operator controls and initialization

C. Output Processing

1. Output process two data channels, one engineering and one science

2. Output process bit rate control, subcarrier frequency control, modulation index control, and attenuation control according to operator inputs

c Software Capabilities of 6050 Computer Program

A. Input Processing

Input process:

1. The equivalent of four telemetry data streams (two engineering, two science) for two spacecraft from the 1108

2. The equivalent of two high-rate science streams (with or without embedded low-rate science) from a Project-supplied digital recording or a negotiated real-time source. Additional low rate science data from 1108 to be embedded, if necessary.

3. High accuracy, command responsive spacecraft position as a function of time in terms of station-centered angles, range rates, and range from the 1108

4. DSS parameters which can be affected by the spacecraft condition. From 1108. (Used for transmission to SCA in long loop, and to vary monitor data in short loop)

Table 28 (contd)

SIMULATION SYSTEM: ALL STATIONS

5. All HSD from up to three DSS, when in long loop mode, discarding all but command and monitor data messages
6. All HSD to three (max) DSS from SFOF disregarding all but Command System and standards and limits traffic (short loop mode only)
7. Processing control messages for 6050 or 1108 and display control messages

B. Output Processing

Output process and format:

1. HSD as listed in footnotes 1 and 2 in combinations not to exceed equivalent of three DSS tracking two spacecraft
2. Wideband data as listed in footnote 3
3. TTY tracking and telemetry as listed in footnote 4
4. Displays of system status and selected data
5. Processing control messages to 1108
6. Anticipated and actual commands to 1108

C. Internal Processing

1. Generate up to two engineering (either rate) and two science (any rate) streams, correctly formatted (frame sync words, etc.), but with controllable pattern data values
2. Commutate the realistic, command responsive telemetry received from the 1108
3. Generate tracking data based upon input station observables for up to three DSS. Either spacecraft from each DSS, other than DSS 14. Both spacecraft from DSS 14, but ranging from only one spacecraft. Affect a maneuver response in the data under input control of maneuver parameters.

Table 28 (contd)

SIMULATION SYSTEM: ALL STATIONS

4. Generate DSS responses to commands in terms of Command and Monitor System data, when in the short loop mode

5. Generate with math models DSS parameters which may vary with change in spacecraft condition (DSN-supplied)

d Software Capabilities of 1108 Simulation Program

A. Input Processing (Project-supplied)

Input process:

1. Program control (including initialization and inputting of constants) from 6050 or 1108 I/O console

2. Anticipated or actual commands from 6050

B. Output Processing (Project-supplied)

Output process:

1. The equivalent telemetry output of two spacecraft

2. High accuracy and precision station-centered angles, range rates, and range

3. DSS parameters affected by commands to spacecraft

C. Internal Processing

1. Generate with math models command responsive telemetry in any legal rate combination, for two spacecraft (Project-supplied)

2. Generate station-centered angles, range rates, and range for three DSS, either spacecraft tracked by any DSS. The data must be command responsive and of high accuracy (Project-supplied)

Fig. 33. DSN/MM '71 Simulation System (all stations)

Table 29. Footnote key to Fig. 34

MONITOR SYSTEM: DSS 12, 14, 41, 51, AND 62

DATA FLOW PATHS

1 DSS Telemetry System data alarms and status

2 DSS Command System data alarms and status

3 Alarms detected by Tracking, Telemetry, and Command Systems, and DSS instrument alarms, for corrective action by station manager

4 DSS instrument standards and limits (predicts, MCD, etc.)

5 DSS status

6 DSS Tracking System alarms, from tracking error detection function located in Monitor computer (See footnote a, A. 1 and C. 1)

7 Instrument status from other DSS subsystems

8 GCF HSD instrument alarms for all high speed traffic inbound to SFOF

9 Time

10 GCF instrument status and data status to 360/75

11 Time

12 Monitor program/operator interplay, plus status displays

13 Data alarms detected by SFOF, and GCF Tracking, Telemetry, and Command Systems, and by periodic processing status messages

14 Video images of digital displays

15 GCF instrument alarms formatted for GCF Control TV display

16 GCF alarm display for corrective action by GCF Control

Table 29 (contd)

MONITOR SYSTEM: DSS 12, 14, 41, 51, AND 62

EQUIPMENT/SUBSYSTEM CAPABILITIES

A Located at MSA

B One full duplex line shared by all systems

SOFTWARE CAPABILITIES

a <u>DSIF Monitor System Phase II Program</u>*

A. <u>Input Processing</u>

Input process:

1. Tracking parameter values and indicator settings from TDH-1 for one S/C consisting of:

    a) Hour angle and declination angle (input, but not processed)

    b) Doppler counts from counter

    c) Range units

    d) VCO reference frequency

    e) Doppler resolver time

    f) Tracking data sample request

    g) Doppler, angle, and range data condition codes

    h) Station ID

    i) S/C ID

    j) Pass number

*Does not apply to Tracking Subsystem DSS 14, Engineering Alternate configuration

Table 29 (contd)

MONITOR SYSTEM: DSS 12, 14, 41, 51, AND 62

2. Input process DSS Telemetry System alarms from 1 or 2 TCP computer programs via the 24-bit parallel registers. (See Telemetry, footnote 8.)

3. Parameter values and indicator settings associated with station hardware configuration for one or two S/C:

    a) SDA parameters and indicators

    b) Decoder parameters and indicators

    c) Receiver parameters and indicators including doppler and range indicators

    d) SSA parameters and indicators

    e) Cassegrain and acquisition aid right or left circular polarization indicators

    f) Antenna servo modes

4. DSS Command System alarms from 1 or 2 TCP computer programs via the 24-bit parallel registers. (See Command, footnote 13.)

5. Instrumentation parameter values consisting of:

    a) Ground AGC and SPE values

    b) Transmitter power

    c) System noise temperature

6. Time for labeling

7. Initialization information and monitor standards (predicts, MCD, etc.) and alarm limits via HSD before pass

8. Operator messages

MONITOR SYSTEM: DSS 12, 14, 41, 51, AND 62

9. Servo angle error values, APS modes and status, and angle data condition from APS computer program

10. Sense switch data from SMC to control local display modes

B. Output Processing

Output process and format:

1. Monitor alarms, parameter values, and indicator settings (full DSS status) into ADSS blocks for HSD transmission to the SFOF-360-75(s) in real time

2. Selected monitor parameters to the station manager console area on a character printer

3. Monitor parameter values, alarms, status for more complete reporting to the station manager on a line printer

4. DIS operator control messages to a character printer

5. Status values to drive the station manager control console monitor display

6. Pass summary at end of pass on HSD

C. Internal Processing

1. The following calculations are made for the Tracking System:

   a) Compute doppler measurement in counts per time unit

   b) Compute doppler residuals using predicts and mean and detrended standard deviation of the residuals

   c) For alarm purposes, compare criteria data with selected tracking data, and compute mean and standard deviation for difference between TDH angles and angle predicts

Table 29 (contd)

MONITOR SYSTEM: DSS 12, 14, 41, 51, AND 62

d) Calculate doppler alarm limits from least squares or Lagrangian extrapolation and perform blunder point alarm calculation using supplied limits

e) Calculate range bias, range mean and standard deviation

f) Calculate noise detection range parameter for range rejection

2. The following calculations are made for the Monitor System:

a) Convert DSS SPE from volts to degrees

b) Convert RF angle errors from volts to degrees

c) Convert transmitter power from volts to watts

d) Convert total system temperatures from volts to °K

e) Maintain cumulative error count for HSD blocks

3. Retain selected parameters to generate pass summary at end of pass

b Communications Processor Program - Monitor portion

In addition to its primary function of automatic data switching for TTY data, the following monitor functions are performed by the CP program:

A. Input Processing

Input process:

1. Operator Commands which control and direct HSD monitoring

2. Data characters which are received for each HSD being monitored. The characters are generated externally by an EDED

Table 29 (contd)

MONITOR SYSTEM: DSS 12, 14, 41, 51, AND 62

on the HSD and are passed to a teletype character generator which outputs encoded characters to the CP. The following input processes are performed by the CP program:

a) The first data character received causes initialization of accounting and status, and calculation of the sample period for the HSD being monitored

b) Subsequent data characters cause the following accounting and status information to be updated:

1) Total number of characters received

2) Total number of parity errors

3) Total number of data blocks in error

4) Total number of out-of-sync errors

5) Total number of carrier-off events

6) Number of characters received in the sample period

7) Number of data blocks in error in the sample period

8) Number of out-of-sync errors in the sample period

B. Output Processing

Output process and format:

1. Data blocks to each active 360/75 comprised of the following:

a) The online CP and its busy rate

b) The mode of the offline CP

c) Accounting information and status on each HSD monitored

Table 29 (contd)

MONITOR SYSTEM: DSS 12, 14, 41, 51, AND 62

2. Data to the CP Digital TV for each HSD being monitored
3. Advisory messages to the CP operator when the carrier on/off status changes for a HSD being monitored
4. Account blocks for each HSD to the CP log tape and to the 360/75 on termination of a monitoring pass

C. Internal Processing

1. The CP calculates the time it is actively processing data as a percentage of time available for such processing in a given period (busy rate)
2. The following internal calculations are performed for each HSD monitored:
   a) Error rate
   b) Total amount of carrier off time
   c) Number of null sample periods
   d) Total number of sample periods

c Part I – The 360/75 Mission-Independent Software System

A. Input Processing

Input process:

1. HSD blocks containing DSIF monitor data:
   a) Alarms, parameter values, and indicator settings in real time
   b) Pass summary blocks at end of pass
2. GCF monitor messages via normal input lines from the CP

MONITOR SYSTEM: DSS 12, 14, 41, 51, AND 62

3. Input process operator messages input from the DSN Monitor Area

B. Output Processing

1. Output process DSN status ODR

   All input data shall be logged on magnetic tape in a format suitable for playback on the 360/75 or for use as input to the 360/75 Post Processor Program

2. Output process digital TV displays

   Eleven DTV displays will be available over 15 computer-driven channels, allowing, for example, simultaneous display of the same information for several tracking stations. Many of the displays have more than one selectable format, allowing the grouping of display parameters as subsets. The displays fall into three basic groups:

   a) DSN Operations

   b) Facility Operations

   c) System Operations

   Each contains a spectrum of displays and format, ranging from gross status and alarming to detailed status and performance data for troubleshooting. By procedurally controlling the assignment of displays to the 15 channels, the number of tracking stations that are simultaneously monitored is selectable to a limit of 15.

3. Output process Monitor I/O Display

   DSN data stream stoppages (360/75, CPS, and the DIS) are output to the Monitor I/O Console when the 360/75 fails to

Table 29 (contd)

MONITOR SYSTEM: DSS 12, 14, 41, 51, AND 62

receive a data block for the given monitor source within a predesignated period

C. Internal Processing

Internal processing of monitor data is restricted to:

1. Display definition
2. Formatting for displays
3. Routing of display data
4. Conversion of monitor input parameters for display purposes

Part II – 360/75 Mission-Dependent Processor

The mission-dependent processor supplies to the mission-independent system accounting and status information on all telemetry streams currently being processed or logged

d Non-Real-Time 360/75 Processing Programs

The following two programs are part of the DSN Monitor System, and are operated in nonreal time

A. Log Processor

This program uses the monitor log tape (DSN status ODR) as input and generates summary prints and plots

1. Input Processing
   a) Input process the log tape (ODR)
   b) Input process control cards via magnetic tape
2. Output Processing
   a) Output process onto magnetic tape, print information controlled by input for actual printing. This tape is the DSN status MDR

Table 29 (contd)

MONITOR SYSTEM: DSS 12, 14, 41, 51, AND 62

b) Output process onto magnetic tape, plot information controlled by input for later plotting on the SC-4020

3. Internal Processing

The program selects and formats, under input control, data from the log tape for printed and plotted output

B. Monitor Criteria Data Control Program

The purpose of MDC Sets is to provide facility configuration displays by which subsystem analysis and performance can be determined.

1. Program Definition

In order to obtain a high degree of flexibility, the program is contained in three main files:

a) Subsystem Configuration (hardware)

b) Configuration Modes

c) Standard MCD Sets

2. Program Characteristics

Characteristics for the MCD program are as follows:

a) MCD Assembly Program, is responsible for receiving requests for standard MCD set activation, modification of a specified parameter within a standard MCD set, generation of a new MCD set, indexing File 3 with the above request, receiving completed request from File 2, and transmission of completed sets to the DSIF via HSD and the 360-75 MCD Processor Program.

Table 29 (contd)

MONITOR SYSTEM: DSS 12, 14, 41, 51, AND 62

b) File 1, Subsystem Configuration, is a description of the equipment issued at the DSIF and associated switch positions.

c) File 2, Subsystem Modes, is a description of the modes of operation, assemblage of equipment, and associated switch positions.

d) File 3, Standard Sets, is a configuration matrix of equipment listed in File 1 and configuration modes listed in File 2.

e) File update system is by the card method. As new equipment is added, new modes of configuration generated, and demands for additional standard MCD sets are required, Files 1, 2, and 3 will be updated by this method.

3. <u>Program Operation</u>

a) Monitor Input/Output CRT and Keyboard is the method by which real-time requests are generated. This is accomplished by a blank format depicted on the CRT and a cursor controlled by the keyboard assembly. To request a standard MCD set, simply fill in the numerical value where applicable. In order to modify a standard set, insert the standard set numerical value as before. On line 1, in addition to the other information, an Alpha numerical sequence is used when defining MCD Set. If standard MCD Set 20 is being used, 20A will be inserted if this is the first modification. Each additional modification to Set 20, if required, will increase in Alpha value. On lines 2

MONITOR SYSTEM: DSS 12, 14, 41, 51, AND 62

through 5 (hardware designations) insert the mode contained in File 2 to be modified. (If modifying Receiver 1 to DO NOT MONITOR, insert the appropriate corresponding mode value in the Receiver 1 blank.) If this is the only parameter to be modified leave all other configurations blank. If the operator is generating a new set, it will be necessary to fill in all configuration mode blanks. The new set will be automatically stored in File 3 unless the Transmit MCD No. blank located on line 1 is completed.

b) All MCD requests are relayed by the MCD Assembly Program to File 3. File 3 is scanned until the standard MCD set number is found. The standard set numerical matrix, unless modified, is transmitted to File 1. When a parameter modification is detected, File 3 will sort and replace the standard set parameter with the modified parameter before transmission to File 1. When a new MCD set is generated via keyboard, File 3 will develop the numerical matrix required before transmission to File 1.

c) The numerical matrix transmitted from File 3 is received by File 1. The numerical sequence pertaining to hardware configuration is massaged by File 1, matched and transmitted to File 2 where the configuration mode sequence is matched.

d) The output of File 2 is received by the MCD Assembly Program and transmitted to the MCD active file.

Table 29 (contd)

MONITOR SYSTEM: DSS 12, 14, 41, 51, AND 62

e) The MCD active file stores all current MCD requests and has the capability to be accessed for transmission of a MCD set generated previously to a station late in activating for a particular project. However, modification of a standard set replaces the standard set in the active file, so if the standard set is needed, it must be re-requested. This in turn will replace the modified set in the active file. The active file also outputs to the MCD processor and HSD router upon each request.

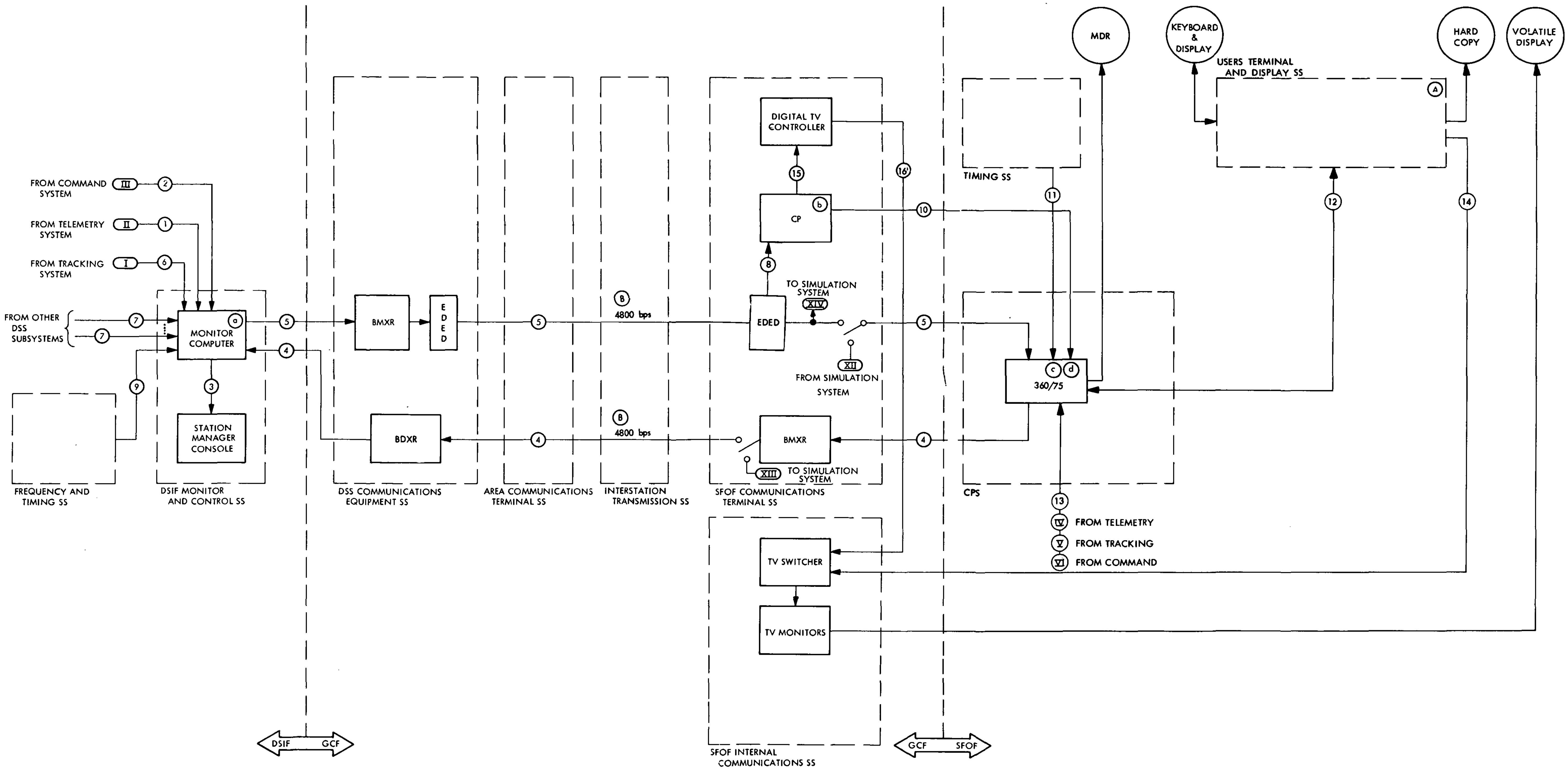


Fig. 34. DSN/MM '71 Monitor System (DSS 12, 14, 41, 51, and 62)

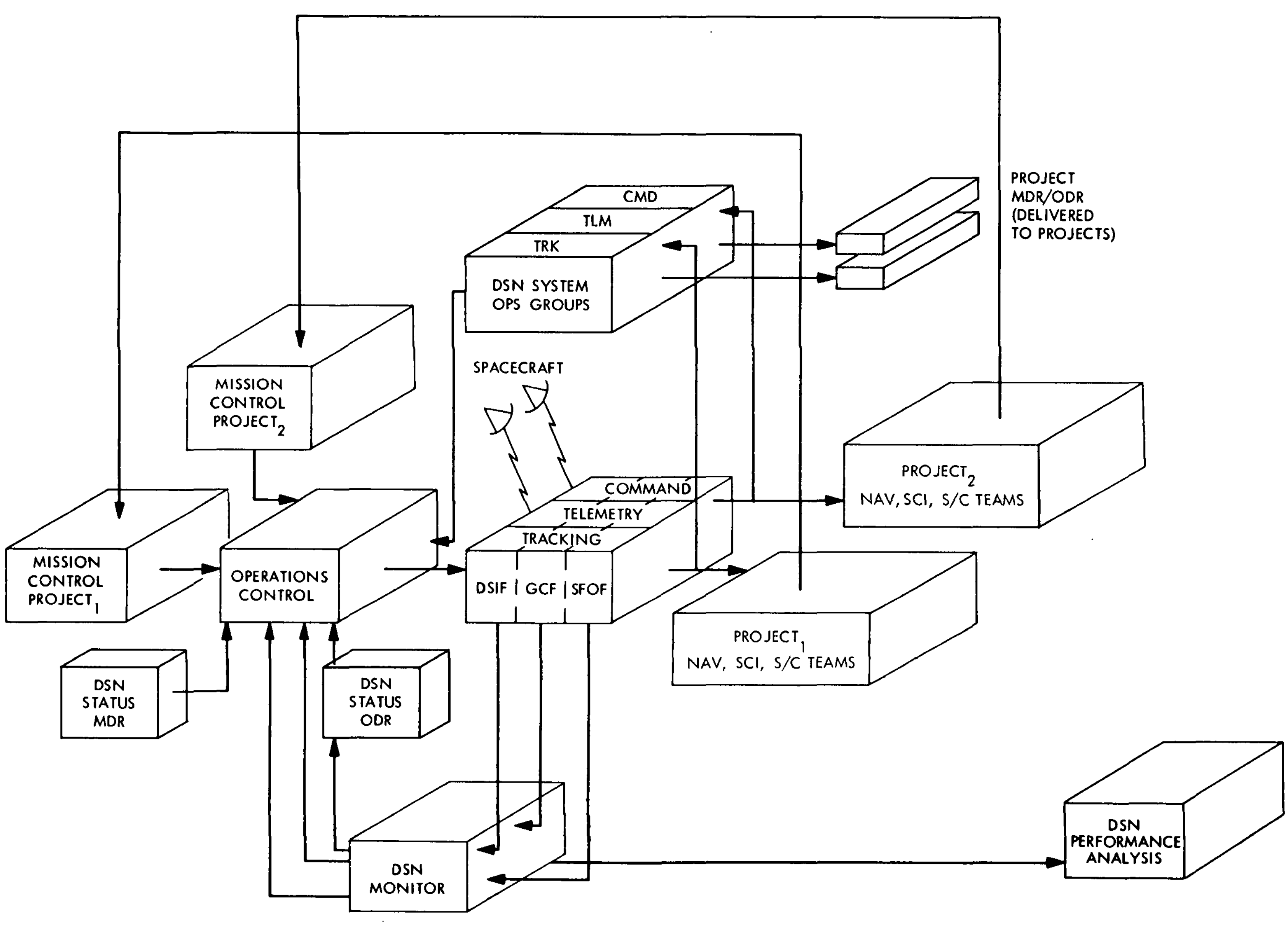


Fig. 35. Conceptual operations structure of the DSN

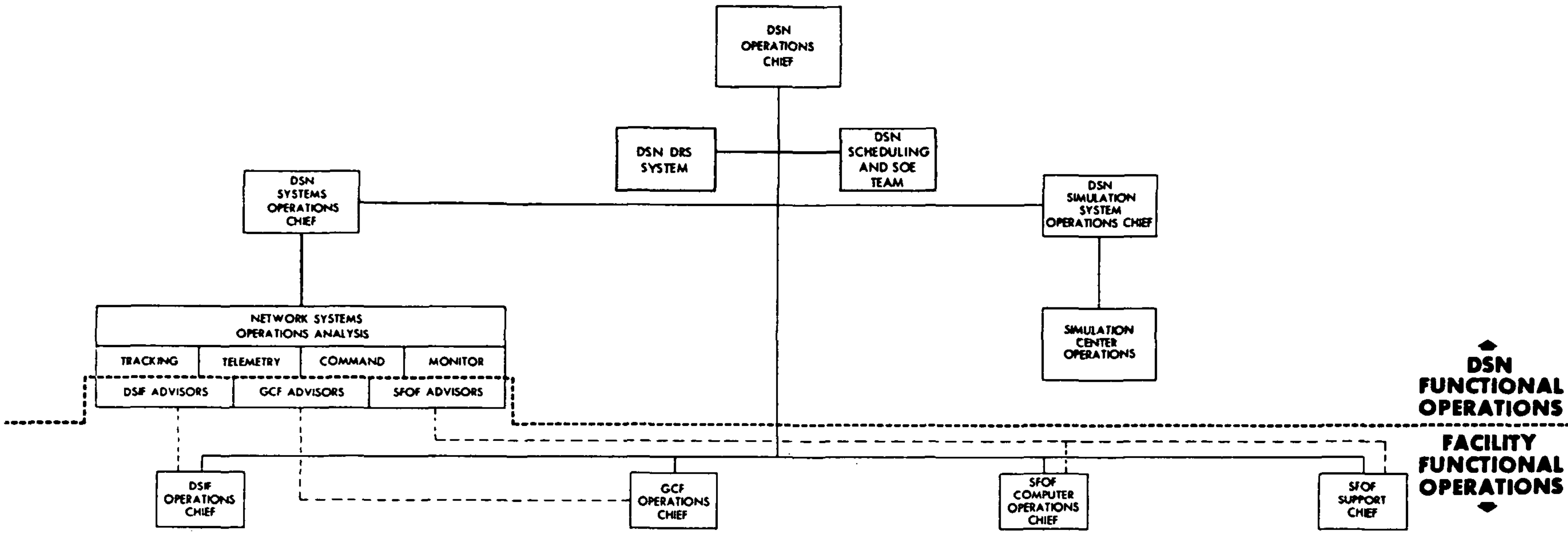


Fig. 36. DSN Mission-Independent Operations organization

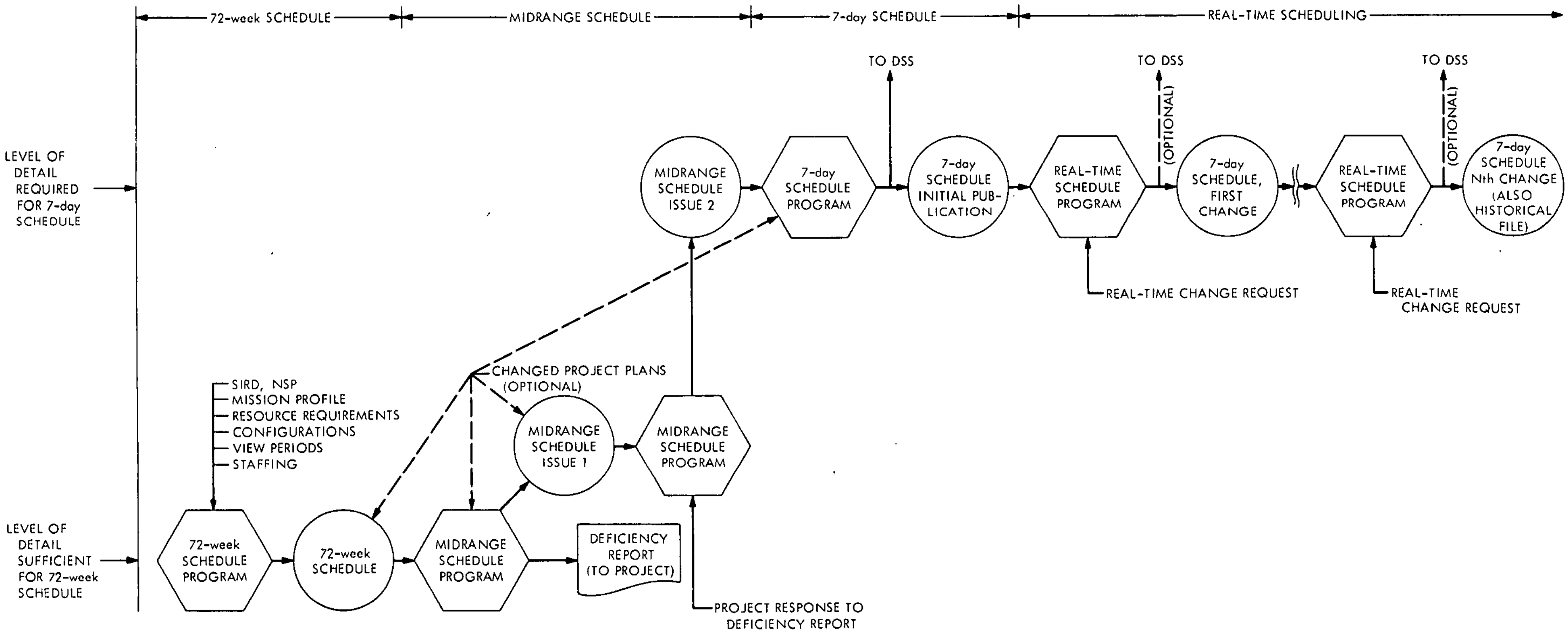


Fig. 37. Network allocation schedules generation

Table 30. Footnote key to Fig. 38

OPERATIONS CONTROL SYSTEM: ALL STATIONS

DATA FLOW PATHS

1. Facility status and alarms for action at Facility Operation Supervisor's initiative
2. Page prints of DSIF Operation control data, e.g., Sequence of Events (SOE), DSIF Standards and Limits
3. Facility internal activity coordination
4. Operational direction
5. Resource requirements and commitments
6. HSD blocks of DSIF Operation control data and DSIF Standards and Limits, e.g., SOE, predicts
7. DSN Monitor display for DSN Operation of DSN Status Information for Project (local MSA only)
8. Facility interface activity coordination
9. System data status, troubleshooting advice, data recall requirements
10. Coordination of Network Standards and Limits
11. Real-time Control of Network Standards and Limits
12. Control of each system data processor, including MDR
13. Control of 360/75
14. Coordination of 1108 control
15. DSN Monitor displays for DSN Operation
16. DSN Monitor displays for Facility Operation
17. DSN Monitor displays for Systems Operation

Table 30 (contd)

OPERATIONS CONTROL SYSTEM: ALL STATIONS

C. Output Processing

1. Produce page prints
2. Flag received lines suspected of errors
3. Insert dummy lines flagging suspected missing lines

f DSN DR Data Bank (Off-line Process with SCF Software)

A. Input Processing

1. Accept discrepancy report data manually transferred from discrepancy report forms to IBM cards
2. Accept instructions on format of output

B. Internal Processing

1. Create master data bank
2. Update individual discrepancy report entries if new data is input relative to that discrepancy report
3. Invoke security measures to protect discrepancy report data

C. Output Processing

1. Output periodic reports to predefined recipients in predefined formats
2. Output special reports in a format which is determined by recipient in near-real time
3. Create historical tape file of data no longer needed in the active data bank

Table 30 (contd)

OPERATIONS CONTROL SYSTEM: ALL STATIONS

C. Output Processing

1. Real-time alarms to SOE program operator of constraints violations

2. Uniquely identify each production run so that the most recently produced SOE for a given period of support operations can be easily and clearly recognized

3. Output to 1443s in DSN Operations Area in SFOF and via Master Control and User Interface Subsystem and HSDL to remote sites

4. Tailor outputs to individual users by suppressing predefined unwanted data from master multimission sequence

5. Output a predefined format to digital television system for display to DSN Operations via CCTV

6. Create historical file (tape) of each SOE production run

e DSIF Page Prints of Operations Control Information

A. Input Processing

1. Accept incoming HSD blocks

2. Check for blocks in errors by means of GCF error code

3. Check for mission blocks by consecutiveness of HSD block serial numbers

B. Internal Processing

1. Format for output to 132-column-line printer

Table 30 (contd)

OPERATIONS CONTROL SYSTEM: ALL STATIONS

d DSN SOE PROGRAM

A. Input Processing

1. Accept Project SOEs in machine language
2. Accept card and manual inputs to build or modify sequences
3. Accept card, manual, and machine language inputs (e.g., Tracking predicts to build or modify a subsequence library)
4. Accept card, manual and machine language inputs (e.g., seven-day schedule in c B.3. above) to build or modify a constraints library
5. Accept card and manual inputs to define or modify format of outputs

B. Internal Processing

1. Identify all events which are keyed as "triggers" and insert subsequence(s) appropriate for each such event
2. Insert event time for each event in a subsequence; fixed delta-T if so defined, or use round trip light time (RTLT), obtained via interface with tracking predicts if delta-T is trajectory dependent
3. Sort and time-order resulting master multimission sequence
4. Check resulting master multimission sequence against library of constraints (e.g., seven-day schedule for simultaneous mutually exclusive events)

Table 30 (contd)

OPERATIONS CONTROL SYSTEM: ALL STATIONS

c DSN Seven-Day Schedule Program

A. Input Processing

1. Accept midrange schedule as base schedule

2. Accept real-time change requests

B. Internal Processing

1. Modify seven-day schedule in accordance with approved real-time change requests

2. Tabulate listing of DSN resources committed at any point in time

3. Tabulate status of uncommitted resources at any point in time

4. Tabulate history of real-time changes to seven-day schedule for selectable intervals

C. Output Processing

1. Transfer seven-day schedule to Master Control and User Interface Subsystem (Program b above) for transmission to remote sites

2. Output items c to digital television (DTV) for display to DSN Operation via closed-circuit television (CCTV)

3. Transfer seven-day schedule to DSN SOE program for use as constraints (see d below)

4. Create historical file (tape) of DSN resources as actually used

Table 30 (contd)

OPERATIONS CONTROL SYSTEM: ALL STATIONS

3. Items 2 and 3 are functions of spacecraft data mode

4. Other parameters are contained in TPAP output (such as uplink AGC) but are not extracted by DSN

b <u>SFOF General Purpose Program in Master Control and User Interface Subsystem to Format Outbound HSD Blocks</u>

A. <u>Input Processing</u>

1. Tracking predicts from Tracking System software

2. Telemetry predicts from TPAP (MM'71 only)

3. DSIF MCD Sets from DSN Monitor Real-Time Software

4. DSN Seven-Day Schedule software output

5. DSN SOE software output

B. <u>Internal Processing</u>

1. Accept data in formats defined by data source

2. Format HSD blocks in formats defined by JPL Document 820-13, DSN System Requirements, Detailed Interface Design

C. <u>Output Processing</u>

Route HSD blocks to SFOF Comm Terminal

Table 30 (contd)

OPERATIONS CONTROL SYSTEM: ALL STATIONS

EQUIPMENT CAPABILITIES

(A) GCF HSDL: one-half of full duplex 4800-bps line with 1200-bit data blocks

(B) DSIF Processor for Operations Control Messages: shared computer with other DSS functions

(C) SFOF/DSN real time and non-real-time processor: redundant IBM 360/75s shared with other system processing and Project processing

(D) Non-Real Time Processor: single Univac 1108 in Scientific Computer Facility (SCF), controlled by DSN; Project analysis software and DSN Simulation System software only

(E) Project MSA: except as noted for display of DSN status (data flow path (7)), applies to local MSA. (Systems Development Laboratory is defined as local MSA.)

(F) DSN Simulation Subsystem: shown for reference only. (See DSN/MM'71 Simulation System description for capabilities.)

SOFTWARE CAPABILITIES

(a) Telemetry Predicts: (For MM'71, obtained from Project analysis program and transferred to 360 via tape)

A. Output Process

1. Predicted downlink AGC as a function of time

2. Predicted subcarrier SNRs as a function of time

Table 30 (contd)

OPERATIONS CONTROL SYSTEM: ALL STATIONS	
18	Control of SOE Software
19	Control of scheduling software (SKED S/W)
20	Reports of DR data via offline processing for Management, DSN Operation, Facility Operation, Systems Operation
21	Reporting of recovery operations
22	Project resource and support requirements
23	Coordination of Sequence Planning
24	Coordination of real-time changes of support requirements
25	Control of Project analysis programs in 1108 and 360/75
26	Technical information exchange
27	Specialized advisory support (not operational direction)
28	Telemetry predicts from Telemetry Predicts Analysis Program (TPAP) via tape interface
29	Not used
30	Control of DSN Simulation Software in 1108
31	Tracking, telemetry and command MDRs
32	Coordination of physical transfer of MDRs to Project
33	Inputs to DSN pass folders
34	Pass folders available (original for current day, microfilm for historical folders) for Project perusal. May send to Project if so negotiated as interface.

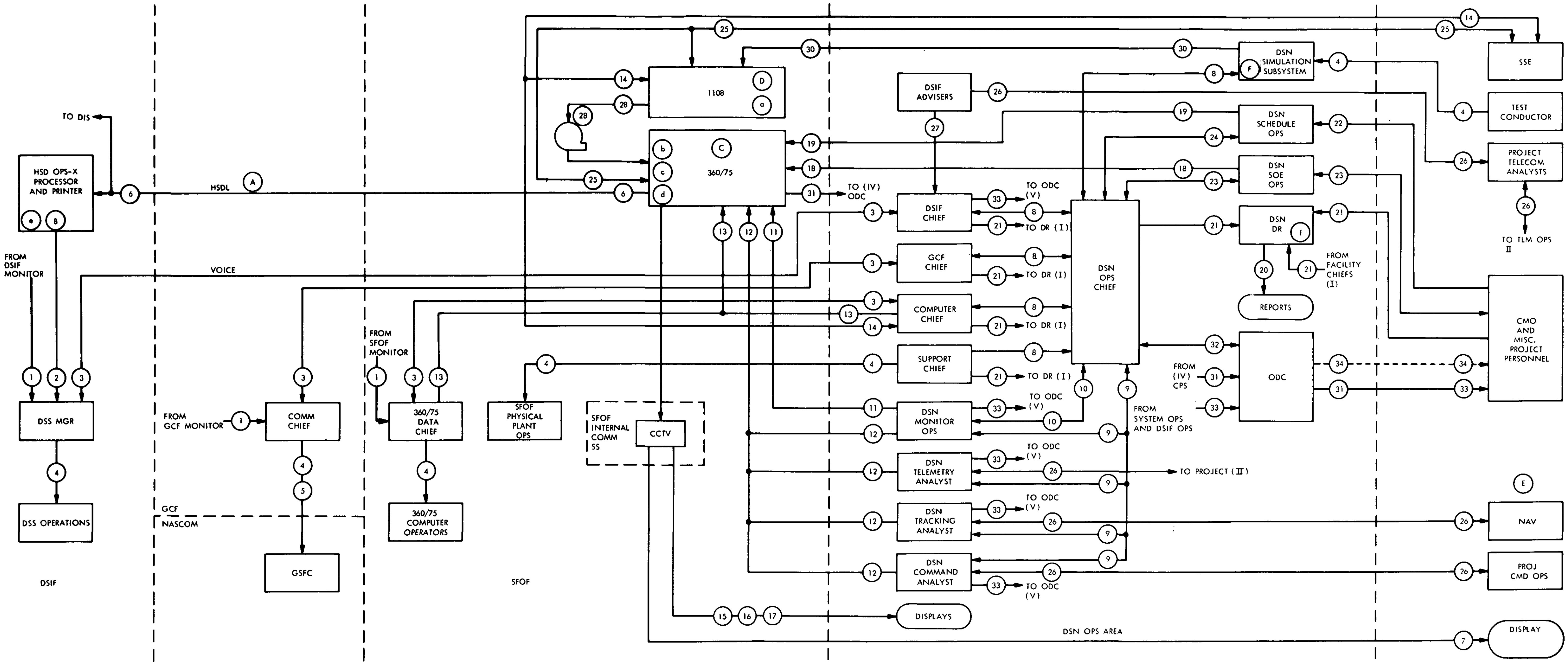


Fig. 38. DSN/MM '71 Operations Control System (all stations)

Page intentionally left blank

Table 31. Mission control and user interface devices

No.	Device
8	2260 CRT with keyboards
6	2260 CRT without keyboards
14	1443 line printers
3	2501 card readers
35	DTV channels (for 35 TV channels)
15	Format request boxes
5	DTV hard copy devices
6	DTV hard copy request boxes

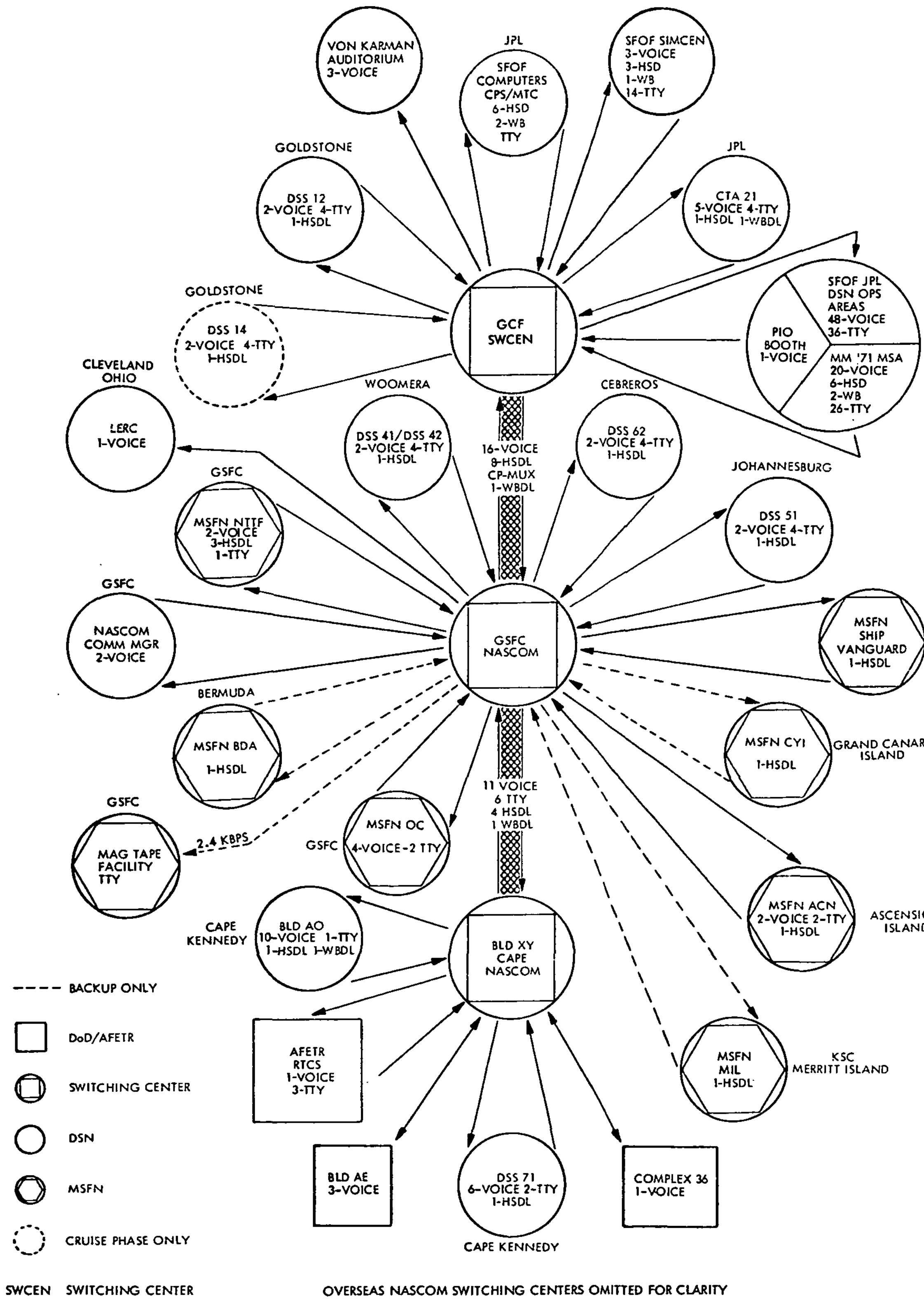
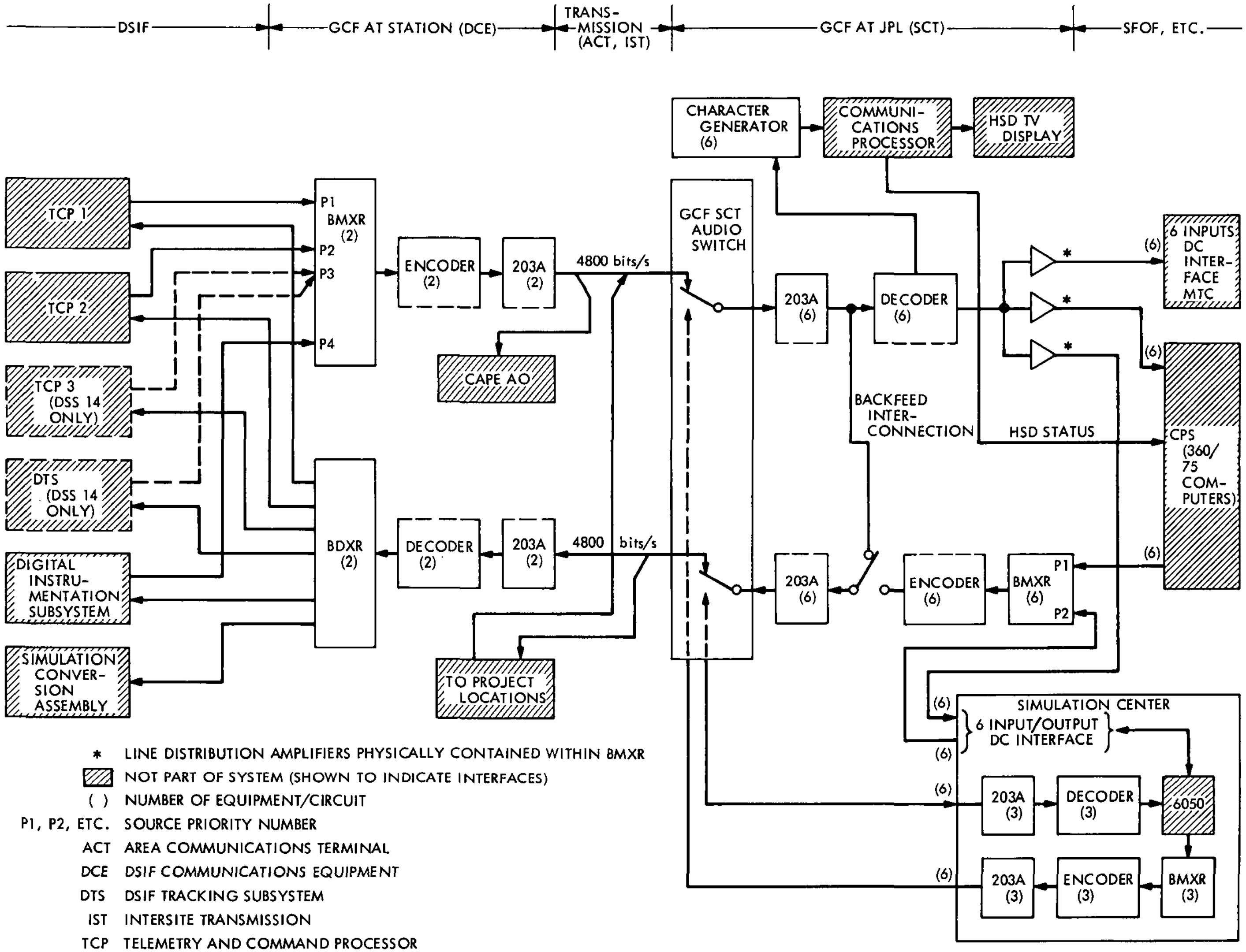


Fig. 39. MM '71 launch and cruise phase operational circuit requirements



*	LINE DISTRIBUTION AMPLIFIERS PHYSICALLY CONTAINED WITHIN BMXR
(hatched box)	NOT PART OF SYSTEM (SHOWN TO INDICATE INTERFACES)
( )	NUMBER OF EQUIPMENT/CIRCUIT
P1, P2, ETC.	SOURCE PRIORITY NUMBER
ACT	AREA COMMUNICATIONS TERMINAL
DCE	DSIF COMMUNICATIONS EQUIPMENT
DTS	DSIF TRACKING SUBSYSTEM
IST	INTERSITE TRANSMISSION
TCP	TELEMETRY AND COMMAND PROCESSOR
203A	DATA SET

Fig. 40. GCF 1971-1972 High-Speed System design

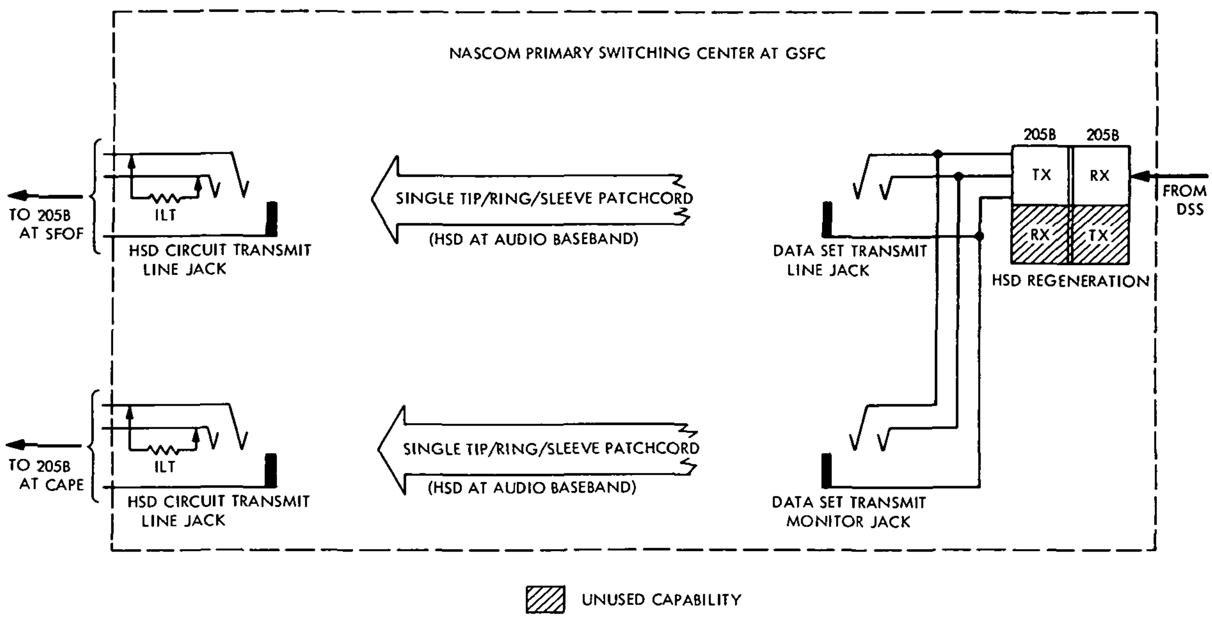


Fig. 41. High-speed data parallel feeding in support of MM '69

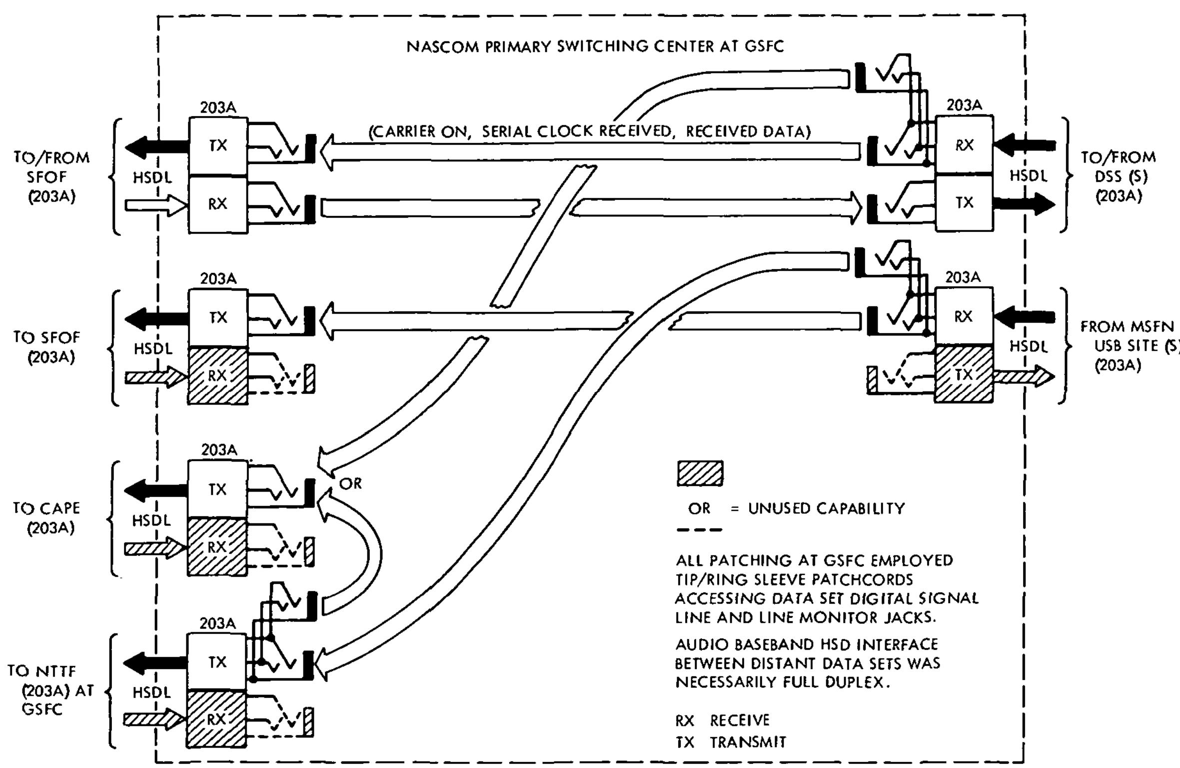


Fig. 42. Parallel feed data set in support of MM '71

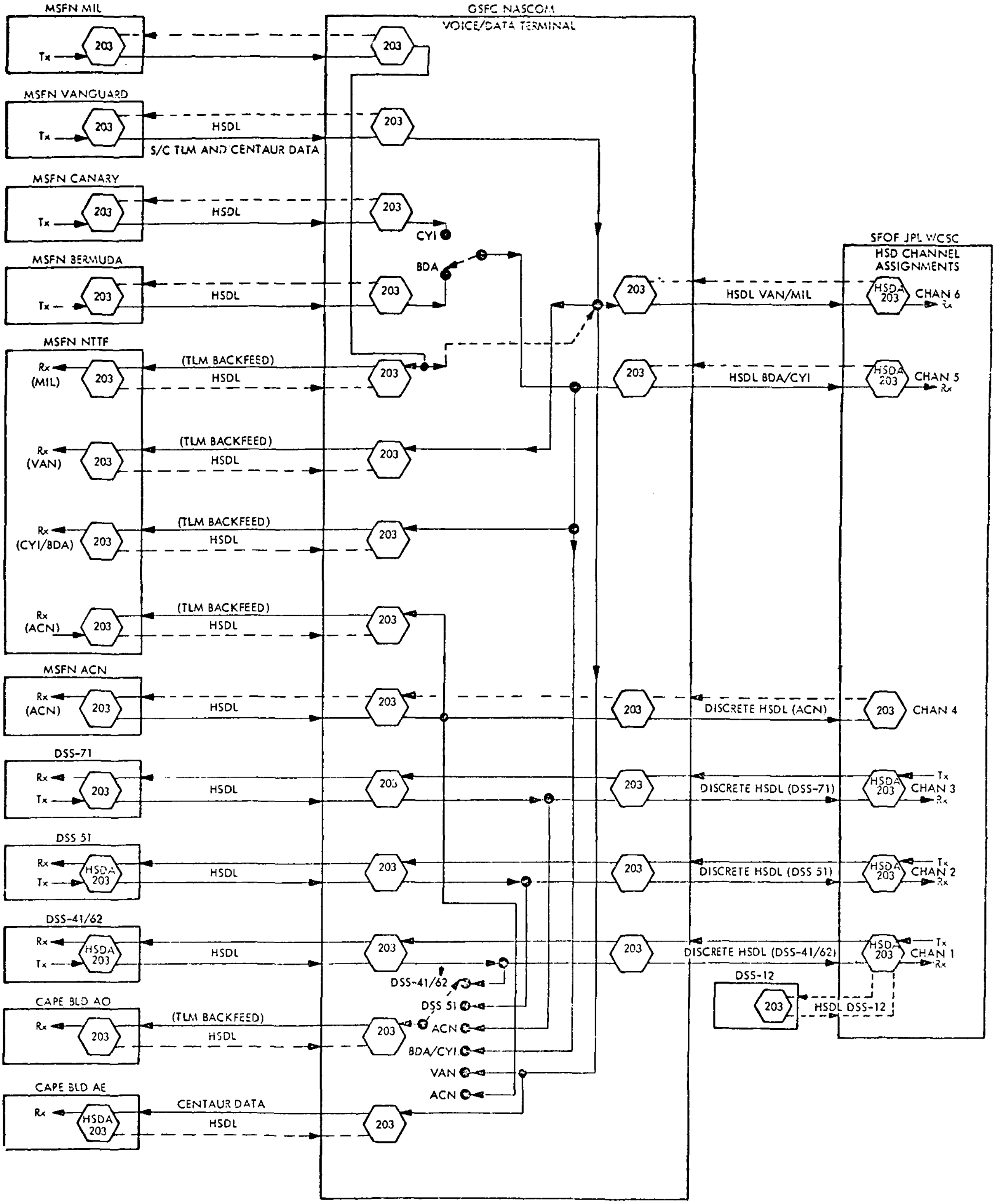


Fig. 43. Parallel feed data set configuration at GSFC

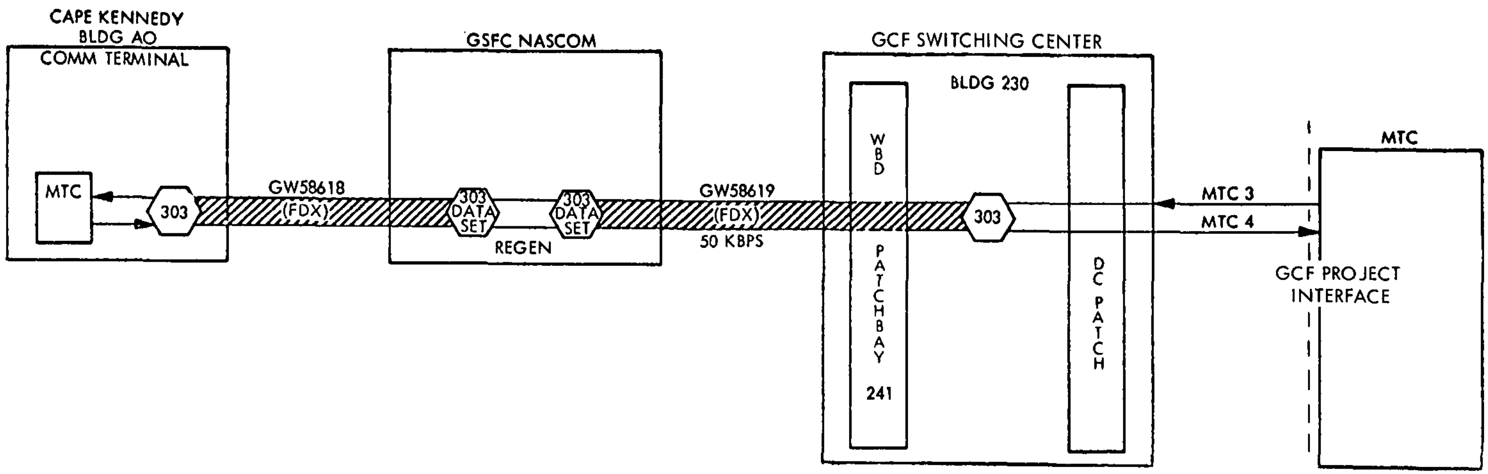


Fig. 44. Mission-dependent wideband data line between SFOF and Cape Kennedy

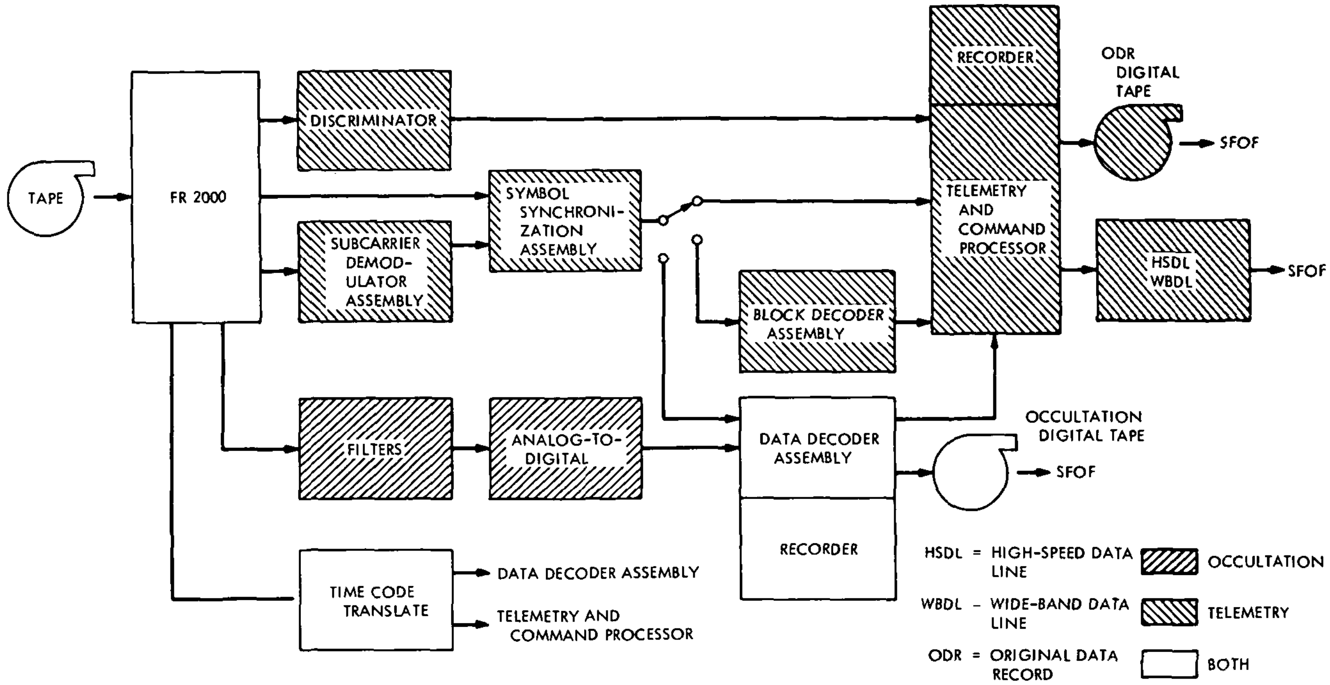


Fig. 45. CTA 21 analog playback capability

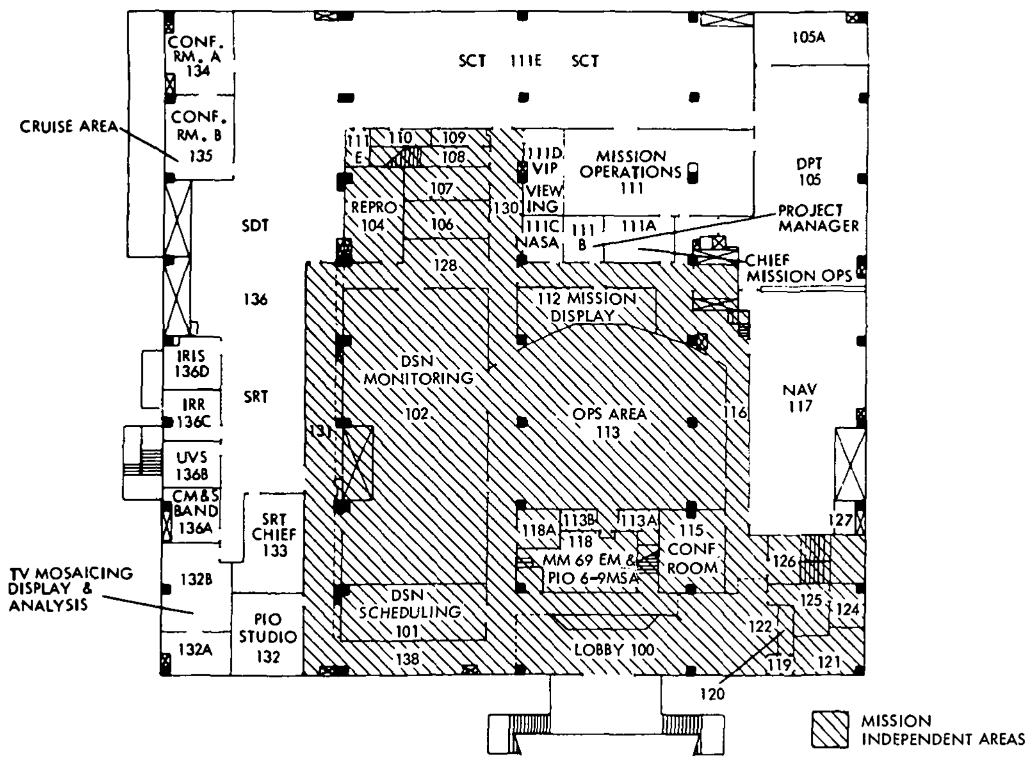


Fig. 46. MM '71 Mission Support Areas, SFOF first floor; general view of support areas

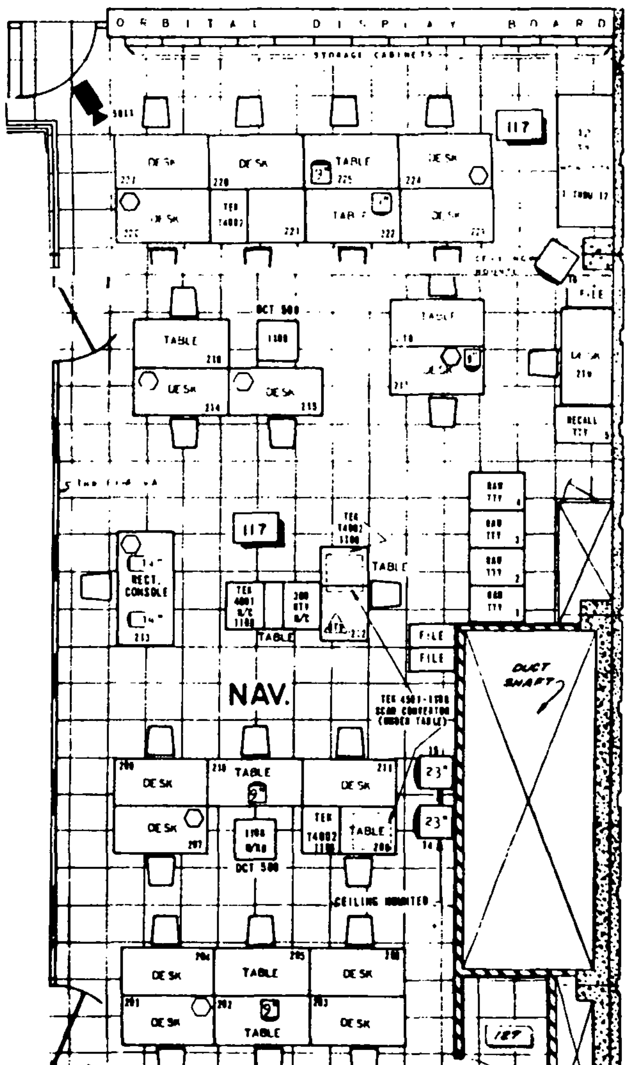


Fig. 47. MM '71 Mission Support Areas, SFOF first floor; NAV support area

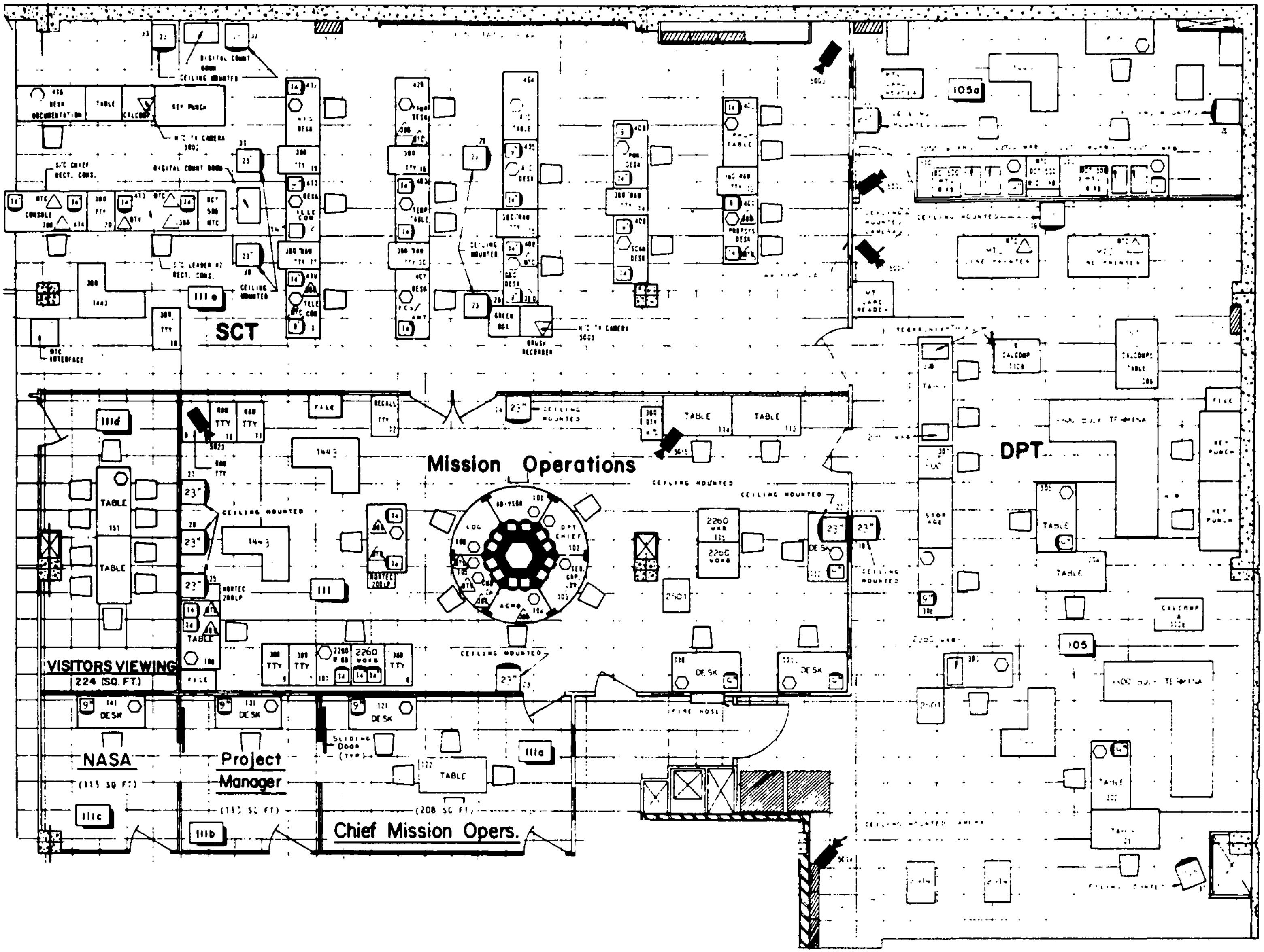


Fig. 48. MM '71 Mission Support Areas, SFOF first floor; Mission Operations, DPT, and SCT support areas

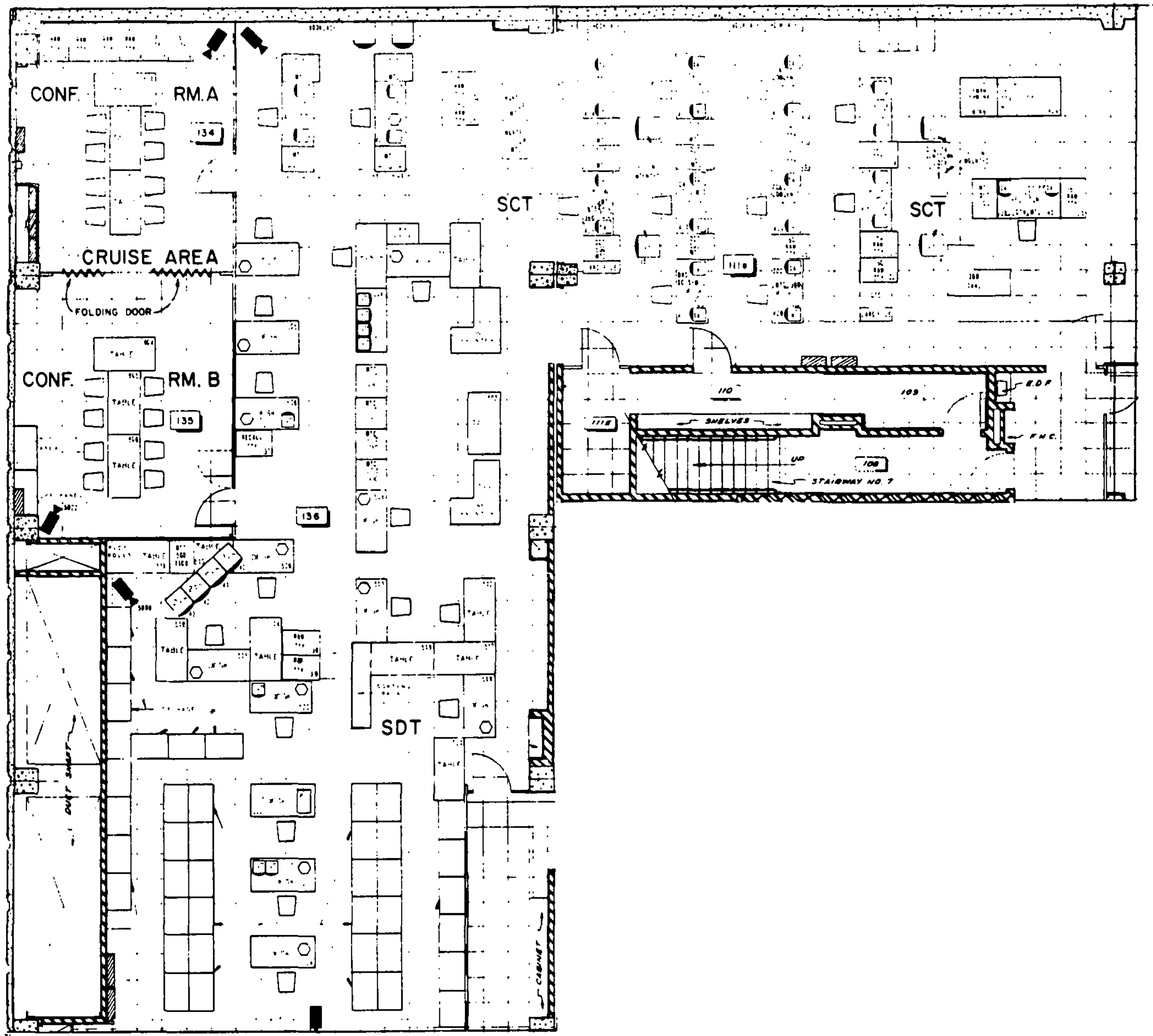


Fig. 49. MM '71 Mission Support Areas, SFOF first floor; SCT (contd), cruise/conference, and SDT support areas

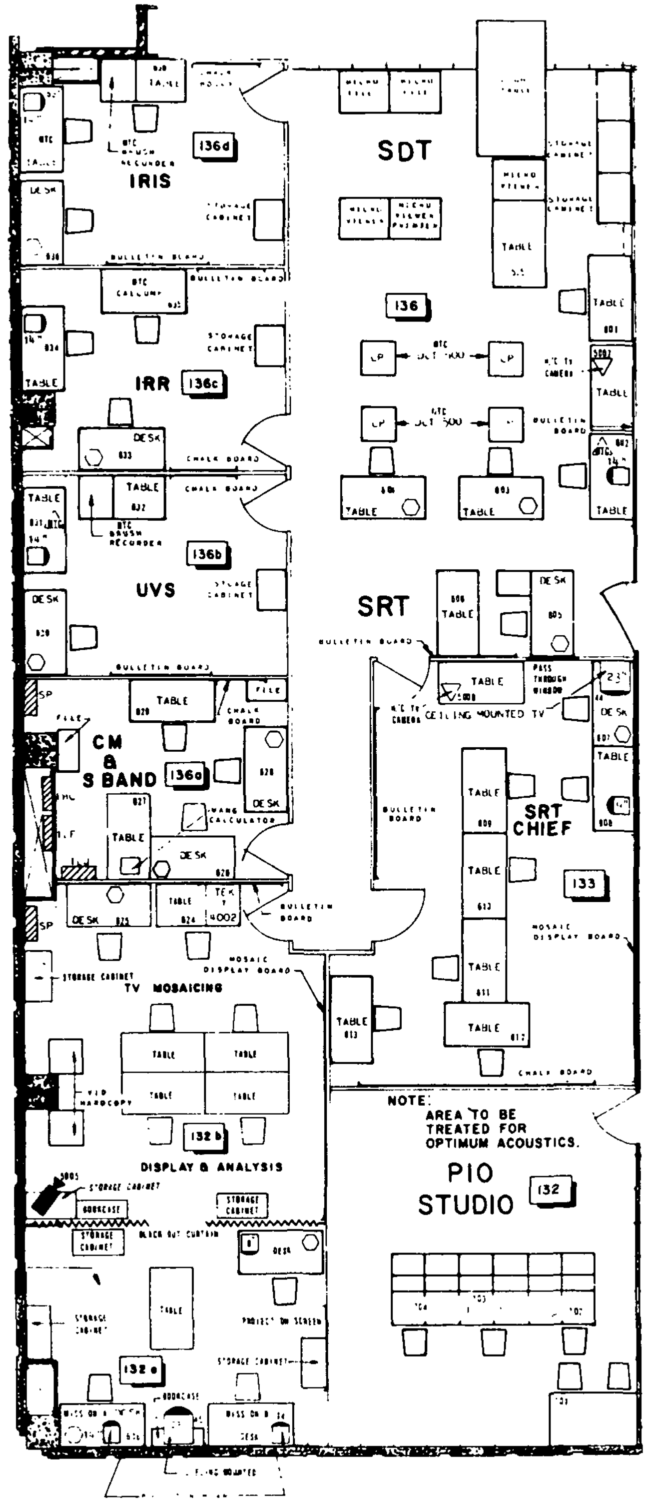
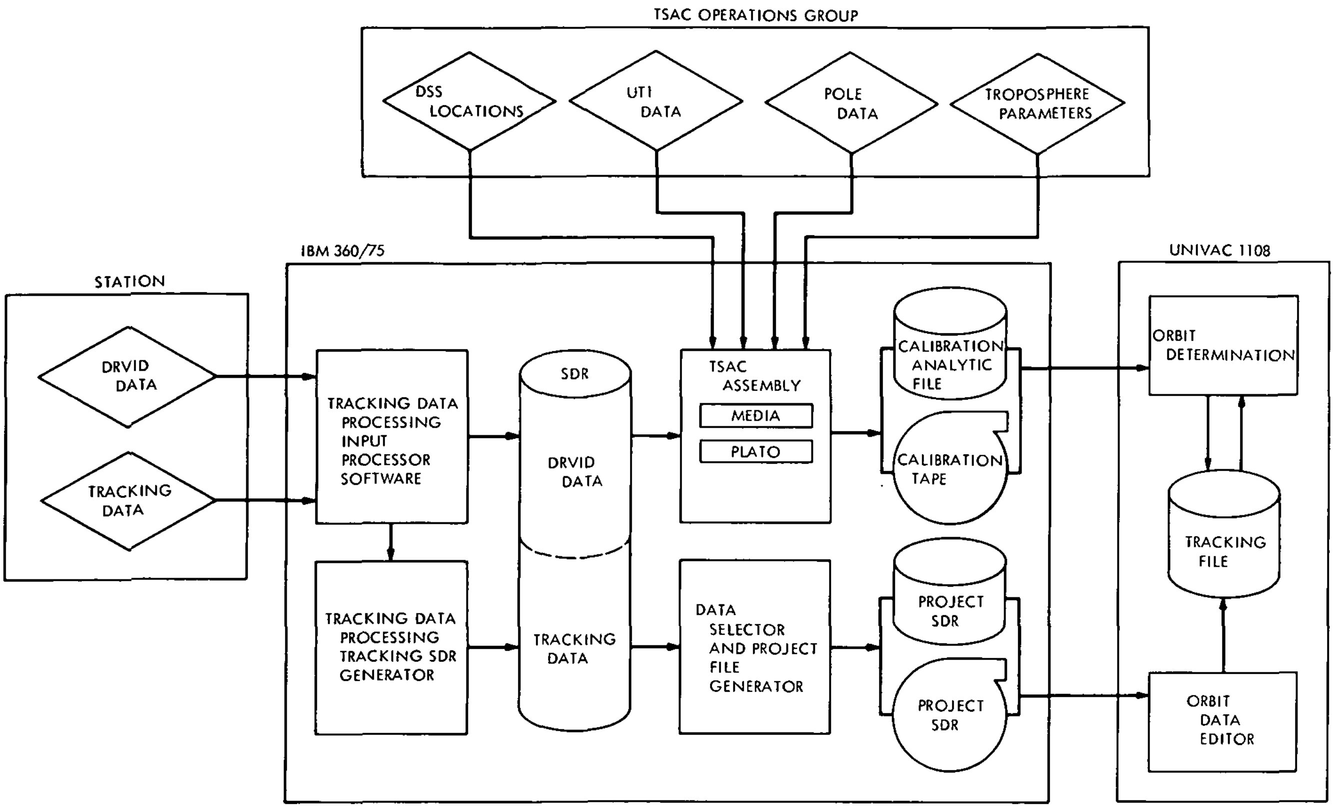


Fig. 50. MM '71 Mission Support Areas, SFOF first floor; SDT (contd), SRT, and adjacent support areas



SDR = SYSTEM DATA RECORD
DRVID = DIFFERENCED RANGE VERSUS INTEGRATED DOPPLER
TSAC = TRACKING SYSTEM ANALYTIC CALIBRATION

Fig. 51. TSAC tracking orbit software subsystems flow diagram

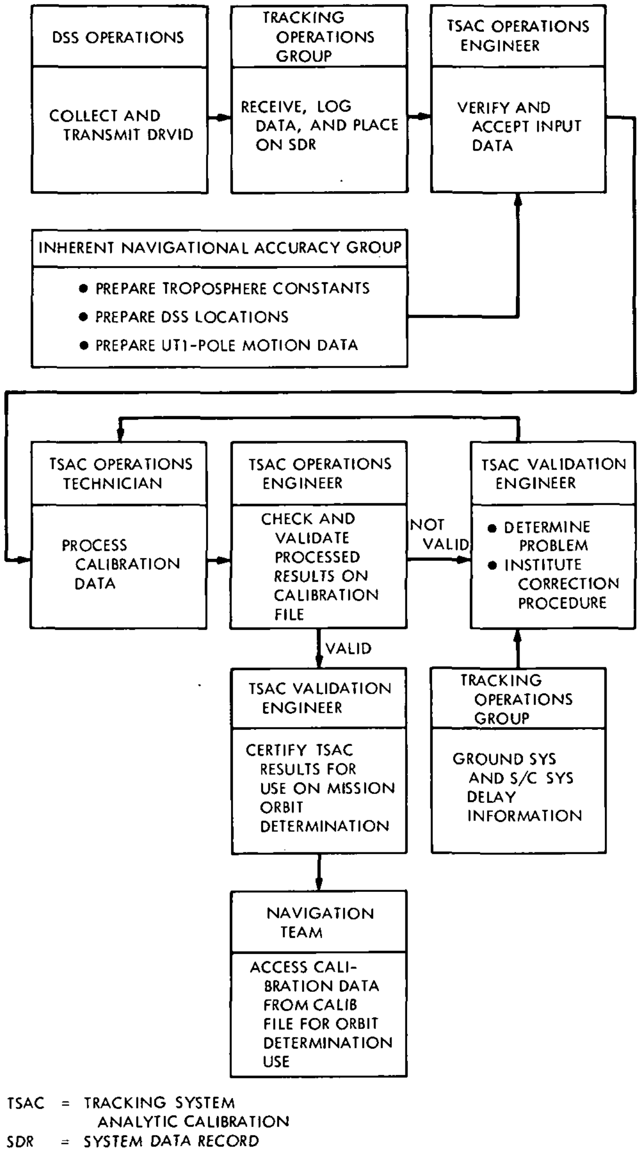


Fig. 52. Planned TSAC operations

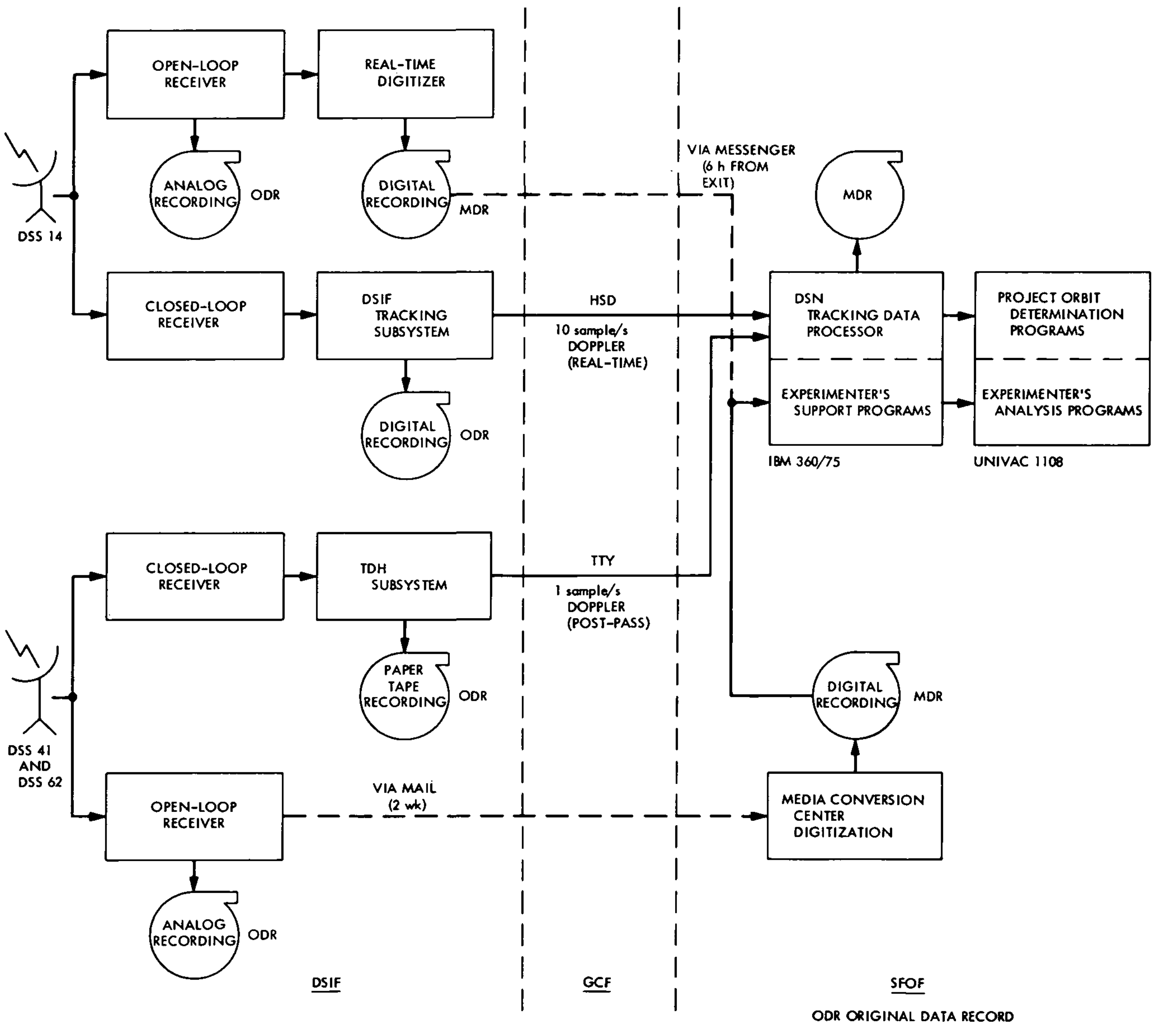


Fig. 53. DSN occultation support configuration

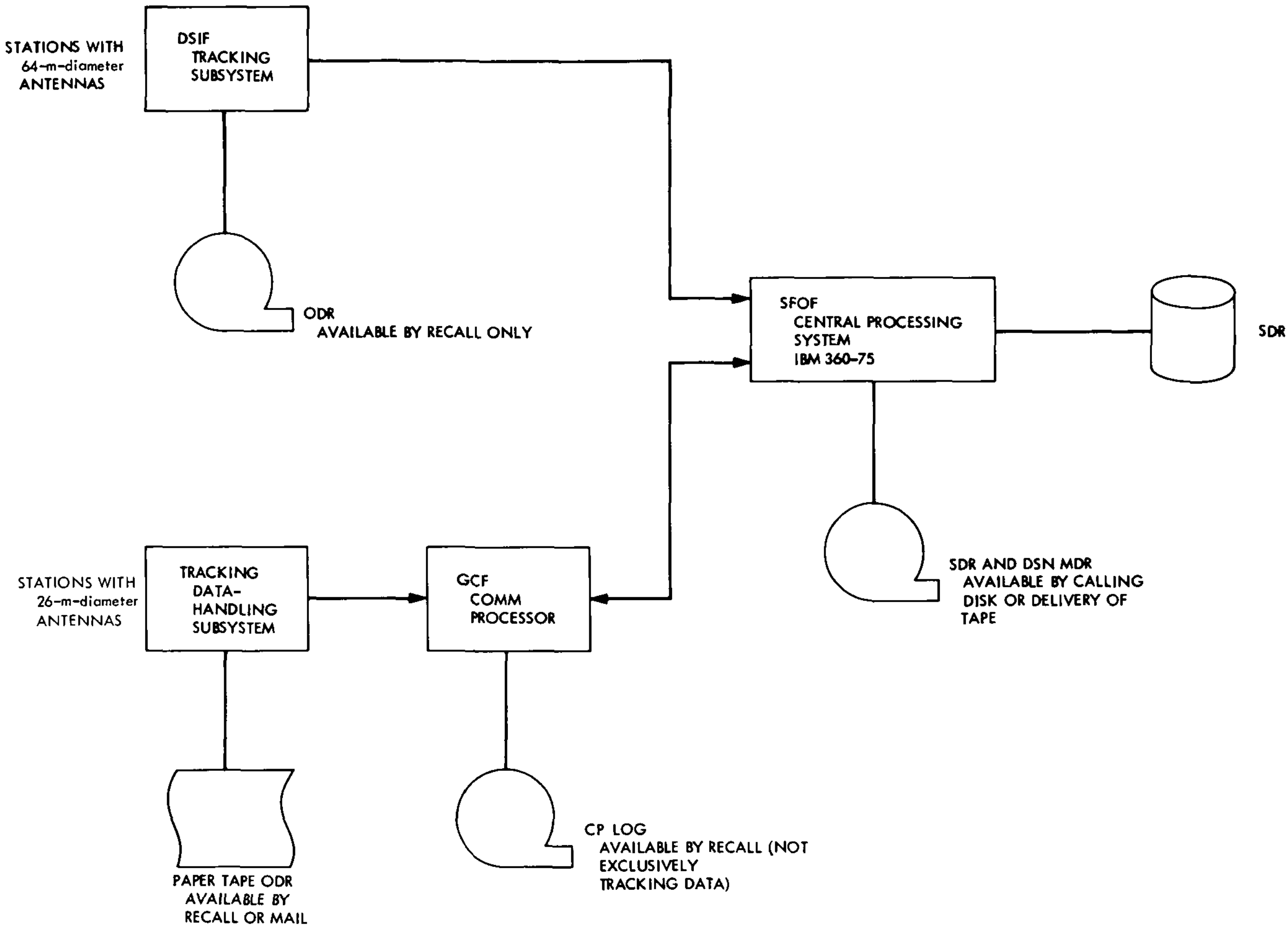


Fig. 54. Tracking Systems records

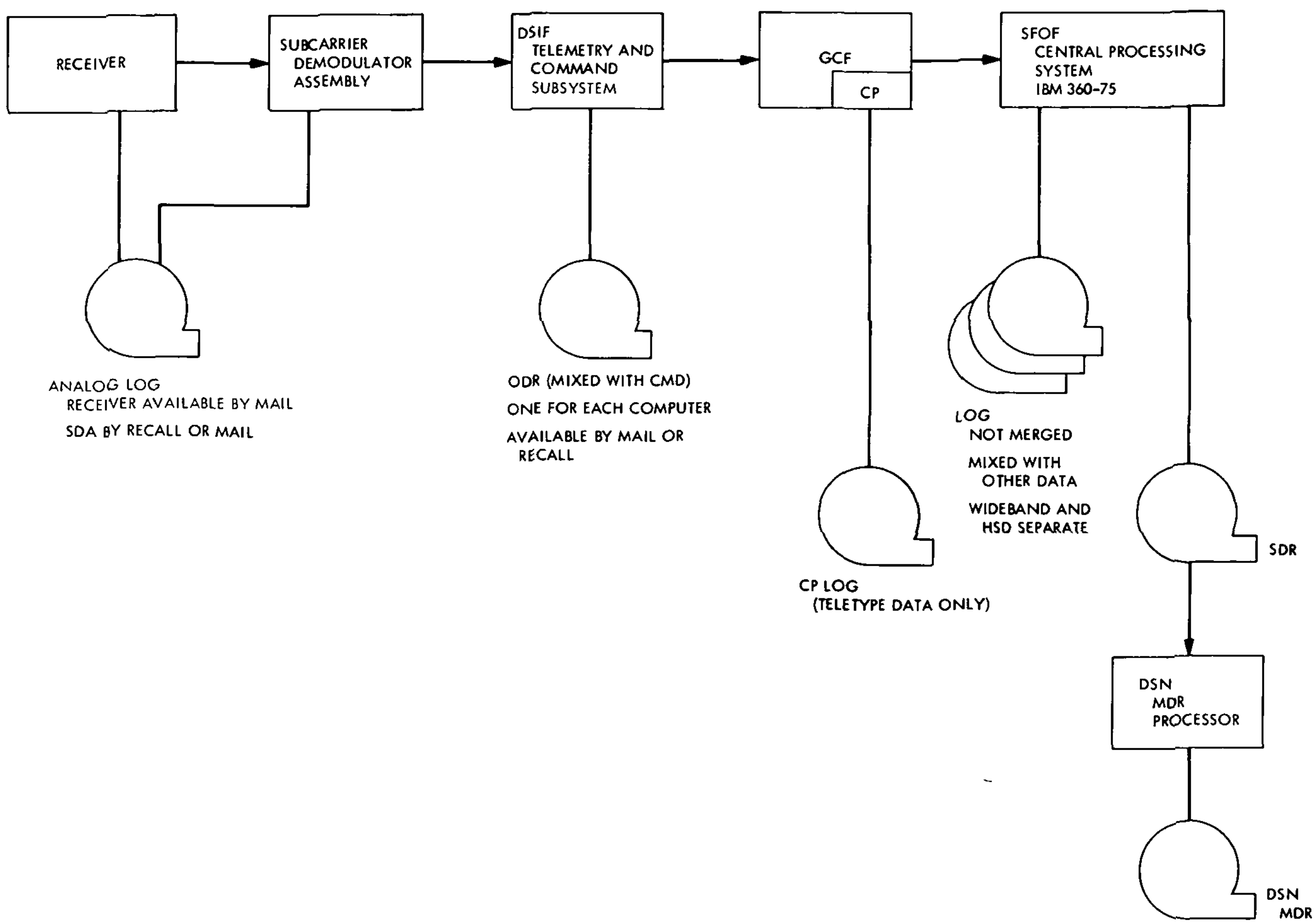


Fig. 55. Telemetry System records

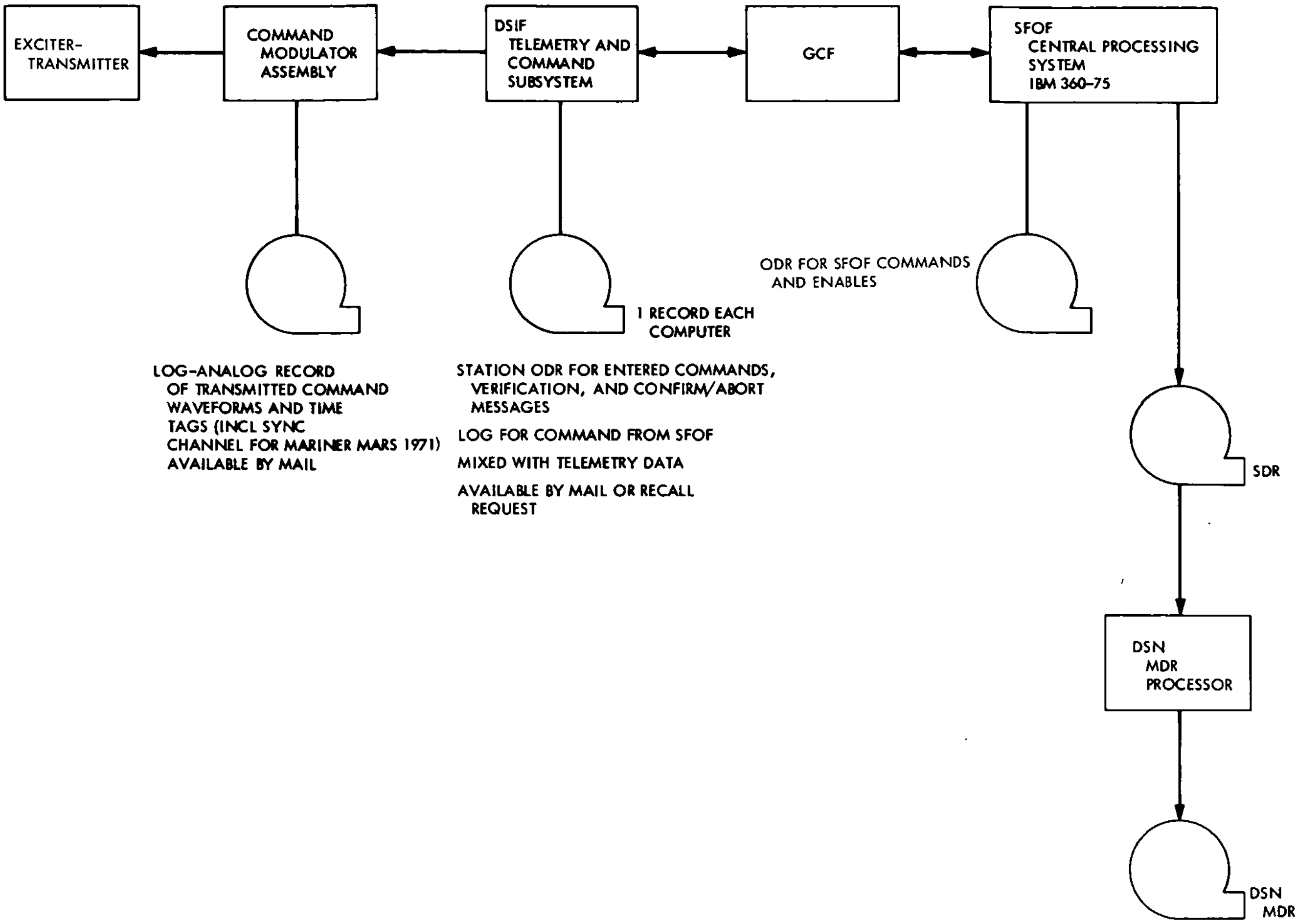


Fig. 56. Command System records

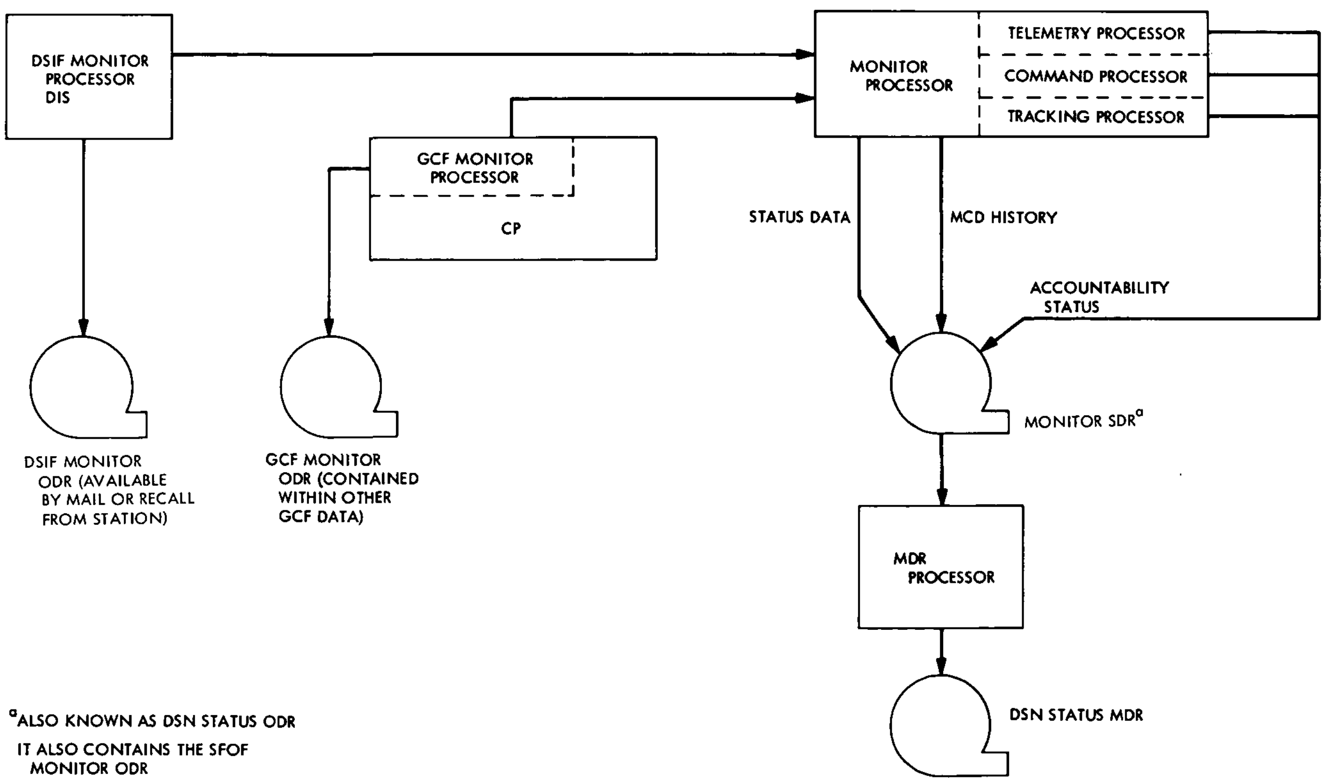


Fig. 57. Monitor System records

A. Test Plan

1. Approach. The TDS test program for the Mariner Mars 1971 Project was developed to be consistent with a Mission Operations Master Test Plan prepared jointly by the Spacecraft System, MOS, and TDS. A TDS test plan was prepared which defined the tests to be run and the cognizant organizations.

Compatibility tests were designed to demonstrate and verify compatibility between the Spacecraft System and Mission Operations. Software tests were designed to demonstrate correct functioning and operational readiness of the software system. Training tests were designed to train TDS personnel in correct operation of the software and data system. Training practice provided to MOS personnel under the Mission Operations Training Plan provided training and testing of TDS personnel and configurations in addition to that provided by the TDS Test Plan.

TDS testing was conducted under the DSN/Spacecraft Compatibility Test Plan, the DSN Test Plan, and the TDS Near-Earth Phase Test Plan. Although the TDS began support of Mission Operations tests some months prior to launch, the support of these tests was used for additional training and testing of the TDS, and supplementary operational verification tests were scheduled to gain more experience with, and correct, operational procedures.

2. DSN/Spacecraft Compatibility Test Plan. The approach to DSN/spacecraft compatibility testing on the Mariner Mars 1971 Project was to demonstrate first a compatible RF interface between the spacecraft and a DSS telecommunications system. Next, the compatibility of the spacecraft and DSN Telemetry and Command Data Systems was to be demonstrated by the proper processing of data. The operational interface was next to be verified by conducting typical flight sequences with representative operational procedures. These tests constituted the design compatibility test (Fig. 58). These tests were to be conducted at JPL between the spacecraft located in the Spacecraft Assembly Facility (SAF) or Environmental Test Facility and CTA 21. The second phase of compatibility testing verified the design compatibility established at JPL by RF verification tests conducted at Cape Kennedy between the spacecraft in Bldg AO and DSS 71.

3. DSN Test Plan. The objectives of the DSN Test Plan were to demonstrate (1) the integrity and internal compatibility of the DSN Data System, (2) the correct functioning of the DSIF, GCF, and SFOF configurations committed to support the project, and (3) DSN operational readiness to support the mission. The plan consists of basically three types of tests: (1) subsystem integration, (2) system integration, and (3) operational verification. The integration tests were designed to demonstrate that the engineering features of the subsystem/system were met. The tests started at the facility level with testing of the mission-dependent equipment and software, in the multi-mission environment. The network system level integration test followed. Upon completion of these tests, the facilities were transferred from the developing to the operational organization, and operational verification tests (OVT) demonstrated the adequacy of operational procedures to conduct mission operations. The DSN test program was essentially complete in March 1971, after which most mission operations testing was conducted.

4. MM '71 MOS Test Plan. TDS-supported tests were conducted by the MOS to demonstrate the capability to execute space flight operations in accordance with the Space Flight Operations Plan (SFOP). Such tests were under the direction of the Assistant Chief of Mission Operations (ACMO), and carried out under the MOS Test Plan. As shown in Table 32, all such tests were supported by the DSN Project Engineering Team, Operations Team, and Simulation Team. All tests were conducted in the SFOF with support as required from SFOF, GCF, DSIF, MSFN, and AFETR. Although outside the DSN Test Plan, these tests afforded valuable training and test experience to the TDS. Table 33 shows the extent of the resources required.

B. Near-Earth-Phase Testing

1. General. The TDS Near-Earth Test Plan was used as the criteria for developing test procedures and schedules.

Three levels of testing were established:

(1) Subsystem prerequisite test.

(2) Systems integration and verification test.

(3) Combined systems and performance demonstration test.

This section summarizes the latter two levels of testing as well as the Near-Earth TDS performance in the MOS training exercise.

2. Test schedule and results. The MOS/DSN/near-Earth-Phase (NEP) integration and performance demonstration tests were conducted over the period from November 1970 through February 1971. The test results were very satisfactory, even though there was a problem on the early data flow tests with no demodulation card and a minor problem in the 8-1/3-bits/s data rate ID from SIMCEN. Two NEP Network Systems Tests were conducted on February 22 and 23, 1971.*

The operations training and readiness (launch and near-Earth) tests were conducted over the period from February 1971 through April 1971. Test results were excellent. Table 34 summarizes near-Earth TDS support of MOS training and tests.

3. NEP system integration and verifications tests. Telemetry and tracking tests are described below.

*Included in DSN/MM '71 Network System Tests listed in Subsection C-5 below; see Table 38.

a. Telemetry. Tests included:

(1) MSFN/NASCOM HSD compatibility: objective/result. Demonstrated compatibility of MSFN formats generated in the 642B computer with the NASCOM HSD (203 MODEM).

(2) MSFN/SFOF telemetry software compatibility demonstration: objective/result. Demonstrated compatibility of MSFN and SFOF software to handle spacecraft telemetry in HSD format from the MSFN to the SFOF, using NASCOM circuits and HSD terminals.

(3) MSFN/SFOF simulation software compatibility demonstration: objective/result. Demonstrated compatibility between the SFOF-HSD formatting of simulation data and MSFN simulation conversion software. Demonstrated ability of the MSFN to reformat the decoded simulation data for HSD transmission loads to the SFOF.

(4) PSK Modulator demonstration: objective/result. Verified proper systems operation of the PSK subcarrier modulator for simulation testing.

(5) Automatic switching unit (ASU): objective/result. Verified ability of the ASU to receive and automatically evaluate several incoming data streams of varying quality.

(6) Simulation System interface test: objective/result. Verified on-line simulation capability between the AFETR and DSS 71.

(7) System data flow test to SFOF: objective/result. Demonstrated interface compatibility and data flow between SFOF, DSS 71, AFETR, and KSC.

(8) MSFN RF compatibility: objective/result. Verified compatibility and evaluated RF interface of the MSFN with live spacecraft and launch vehicle telemetry data. Evaluated 642B software in data source selection.

b. Tracking. Tests included:

(1) S-Band metric data and acquisition predict test: objective/result. Verified compatibility of DSN and MSFN formats with the AFETR RTCS and evaluated processing accuracy and capability of the RTCS. Also, verified format and content of RTCS real-time predicts that were planned for MM '71 mission. Demonstrated capability of the GRTS to generate frequency predicts messages.

(2) Mapping to Mars encounter: objective/result. Determined accuracy of RTCS mapping program output parameters as compared to the SFOF mapping program output parameters.

(3) Centaur guidance telemetry data test: objective/result. Tested data flow interface of Centaur guidance telemetry orbital elements (state vector) between the Central Instrumentation Facility (CIF) at KSC and the RTCS. The test verified that the RTCS can accurately map these orbital elements to planetary encounter.

(4) Vanguard C-band test: objective/result. Tested C-band metric data flow interface between Apollo ship Vanguard and the RTCS. This test verified that the RTCS can accept and process VAN data to the accuracy required.

4. Combined system and performance demonstration test: objective/result. This test evaluated the effect of combined system operation on communication loading and operational methods. The test demonstrated total near-Earth telemetry system end-to-end data flow when all subsystems were activated for support.

5. MOS training exercises. Near-Earth TDS participation included preparation of simulated metric data packages for use in MOS training exercises. The packages of data were prepared by the AFETR Real-Time Computer System and sent to the Simulation Center at the SFOF so that RTCS participation could be simulated.

In addition to the above, facilities of the near-Earth TDS participated actively in MOS tests summarized in Table 34 above.

6. DSS 71 activity. A summary of the DSS 71 activity for MM '71, including station hours for each activity code, over the period September 1969 through June 1970 is given in Table 35.

C. Deep Space Phase Testing

1. Compatibility tests. Deep space phase compatibility tests are described below.

a. General. The DSIF/MM '71 flight spacecraft compatibility tests were divided into three phases:

(1) Phase I, design compatibility. Phase I tests were conducted with the fully assembled proof test model spacecraft (PTM). The purpose of the tests was to verify that the spacecraft design and the DSIF were mutually compatible. Tests were conducted with the spacecraft located in the SAF and the Environmental Test Laboratory (ETL), with air link to CTA 21.

(2) Phase II, design compatibility verification. Phase II tests involved each flight spacecraft in conjunction with CTA 21 and DSS 71. The purpose of the tests was to verify data from the Phase I compatibility tests of the PTM.

(3) Phase III, mutual interference compatibility. For the first time, two spacecraft were to have been tracked

simultaneously by one DSS. Phase III tests were conducted to determine if there was any interference when commanding either spacecraft or processing two telemetry data streams.

b. Test definition and objectives. Included below are RF system, telemetry system, command system, and ranging system tests.

RF system tests. These tests were as follows:

(1) Carrier acquisition and threshold. Tests included:

(a) Downlink threshold, one-way. This test verified DSIF capability to acquire RF carrier phaselock vs received signal level for specified spacecraft telemetry modes, exciter/TWTA modes, and DSIF receiver bandwidth. Actual measured RF threshold was compared with the theoretical value.

(b) Uplink threshold, two-way. These tests verified the spacecraft transponder receiver capability to acquire RF carrier phaselock vs received signal level. Actual measured RF threshold was compared with theoretical value. Test conditions were as follows: (1) Test 1 without uplink modulation, (2) Test 2 with command modulation ON after acquisition, and (3) Test 3 with command and ranging modulation ON after acquisition.

(c) Downlink threshold, two-way. The two-way RF carrier phaselock capability was verified under the stated test conditions. Command modulation was ON. The P_c uplink of -150 dBmW was below command threshold.

(2) Spacecraft receiver pull-in range. The spacecraft receiver pull-in range was verified vs uplink signal levels. Test conditions were as follows: (1) No uplink modulation, (2) This test was conducted immediately following the test of spacecraft receiver best-lock frequency (paragraph 7 below), and (3) Record time for lockup as uplink was detuned ±20 kHz, then transmitter is turned on.

(3) Spacecraft receiver tuning range and rate. The spacecraft receiver tuning range and rate were verified while the spacecraft RFS VCO was varied (maintaining two-way phaselock). Test conditions were as follows: (1) No uplink modulation, (2) Range of frequency offset: ±20 kHz, (3) Minimum tuning ramp rate: 20 Hz/s, and (4) Verified tuning rates to be used operationally.

(4) Residual phase jitter. This test verified that the overall residual phase jitter for each exciter/TWTA mode and for both one-way and two-way lock modes was within mission requirements at high signal levels with no uplink modulation. DSIF receiver bandwidth is 12 Hz.

(5) RF link spectrum analysis. This included both uplink and downlink analyses as follows:

(a) Uplink spectrum analysis. The uplink carrier suppression and the sideband structure were investigated for each uplink modulation mode to verify that there was no degradation in spacecraft operation due to spurious radiations from the DSIF transmitter of uplink S-band interchannel interference. The test also locates any false points of the spacecraft transponder over the entire VCO tracking range. Test conditions were as follows: (1) Uplink spectrum photos from DSIF transmitter at ±40 kHz (S-band) spectrum analyzer display setting, (2) No uplink modulation during sweep, and (3) Sweep ±40 kHz (S-band).

(b) Downlink spectrum analysis. The downlink carrier suppression and sideband structure were investigated for each spacecraft telemetry mode, exciter/TWTA mode with ranging channel ON and OFF, ranging and command modulation ON, to verify that there was no degradation in DSIF operation due to spurious radiations from the spacecraft transponder or downlink S-band interchannel interference. Test conditions were as follows: (1) Spacecraft ranging channel ON; uplink modulation ON, (2) Sweep ±40 kHz (S-band), and (3) Plots and photographs required.

(6) Tracking range and rate. This test verified that the spacecraft receiver would remain phase-coherent under a condition of constant uplink power and orbital doppler rates. At the same time, equivalent tests were run to demonstrate that the DSIF receiver would remain phase-coherent during high orbital doppler rate conditions. Test conditions were as follows: (1) No uplink modulation, and (2) Doppler rate: 20 Hz/s (S-band); minimum doppler range: ±20 kHz (S-band).

(7) Spacecraft receiver best-lock frequency. This test verified the spacecraft receiver best-lock frequency as established during subsystem testing. Test conditions were as follows: (1) No uplink modulation, and (2) The spacecraft auxiliary oscillator was inhibited and the VCO frequency was measured one-way.

(8) Downlink carrier suppression. The carrier suppression for selected spacecraft modes was measured and verified within mission requirements.

(9) Auxiliary oscillator frequency. This test determined each auxiliary oscillator center frequency. The warmup characteristics of selected exciter/auxiliary oscillator combinations were measured when switching from one exciter to the other. There was no uplink modulation.

Telemetry system tests. These tests were as follows:

(1) Bit error tests. These tests verified that the overall telemetry system operated as specified. The tests were conducted for both the engineering and science channels vs selected spacecraft telemetry modes, two-way lock mode, and exciter/TWTA modes. Tests with ranging modulation ON and OFF were compared to verify no degradation in the telemetry channel due to the ranging channel modulation. S-band telemetry interchannel effects were also verified.

(2) Telemetry subcarrier acquisition. These tests verified the capability and time required by the DSIF MMTS to acquire and maintain telemetry subcarrier phaselock loop in specified spacecraft telemetry modes at expected downlink signal levels, one-way and two-way mode, exciter/TWTA modes, and uplink modulation mode (ranging and command modulation simultaneously). Test conditions were as follows: (1) DSIF receiver bandwidth: narrow (12 Hz), and (2) DSIF SDA bandwidth: narrow.

(3) Bit sync acquisition. These tests verified the capability and time required by the DSIF MMTS/Project TCP software to acquire and maintain bit sync in each channel for specified spacecraft telemetry modes under the same conditions as the telemetry subcarrier acquisition test.

(4) Frame sync acquisition. This test verified the time required by the TCP to acquire engineering telemetry frame sync (and reacquire after sync loss) for specified spacecraft telemetry modes under two-way lock conditions vs downlink signals levels under the same conditions as the telemetry subcarrier acquisition test.

(5) Four-channel operation. This test verified that the MMTS configuration operated simultaneously as specified on both engineering and science data channels at selected downlink signal levels. Selected spacecraft telemetry modes in which both channels are active were tested. The tests were conducted with the ranging modulation ON. Also, the investigation of selected spacecraft telemetry modes of two spacecraft were accomplished simultaneously. This test was not performed with the proof test model.

(6) Subcarrier phase jitter and frequency. This test verified the phase jitter of each spacecraft telemetry subcarrier.

(7) Doppler conditions. These tests verified that the MMTS functions within specifications under the doppler conditions expected during the mission. Doppler offsets introduced into the MMTS reference were as follows:

(a) Channel 1: ±0.227 Hz (SDA).

(b) Channel 2: ±0.330 Hz (SDA).

(c) Channel 3: ±2.5 Hz (SDA).

(8) Bit rate measurement. This test verified the telemetry bit rates.

Command system tests. These tests were as follows:

(1) Command polarity verification. This test verified that the overall command system signal polarity is as specified.

(2) Operational capability. This test verified that the spacecraft will accept and execute commands at FCS design threshold and at strong uplink signal levels. Capability was evaluated throughout the compatibility test. Test conditions were as follows:

(a) There was no special command testing.

(b) Only those commands approved by the Spacecraft System Test and Operations Manager were transmitted from CTA 21 during these spacecraft tests.

(3) FCS sync acquisition. This test verified the average time required by the FCS to acquire and maintain sync lock with the DSIF MMCS uplink RF system vs uplink signal level and spacecraft receiver static phase error (SPE). Test conditions were as follows:

(a) After two-way acquisition command modulation ON.

(b) Test 1: S/C RCVR best-lock frequency.

(c) Test 2: S/C RCVR best-lock frequency + 20 kHz offset (S-band).

(d) Test 3: S/C RCVR best-lock frequency - 20 kHz offset (S-band).

(4) Command capability under doppler conditions. This test verified that commands may be transmitted, received, and executed under mission expected doppler rates and uplink signal levels. Test conditions were as follows:

(a) Ramp to ±20 kHz (S-band).

(b) Doppler rate: 20 Hz/s (S-band).

(c) Commands to be transmitted and verified at 2 kHz (S-band) intervals.

(5) Command system degradation caused by ranging modulation. This test verified that the degradation in RFS/FCS performance caused by ranging modulation is within mission requirements. Test conditions were the same as the command capability under the doppler conditions test, described above.

Ranging system tests. These tests were as follows:

(1) Polarity verification. This test verified that the spacecraft transponder ranging channel performs its turnaround function at the specified signal polarity. This test was combined with the acquisition test, described below.

(2) Acquisition test. This test verified the probability of correct ranging correlation under signal level conditions expected throughout the mission vs exciter/TWTA mode and static doppler conditions. Test conditions were as follows:

(a) Test 1: S/C RCVR best-lock frequency.

(b) Test 2: S/C RCVR best-lock frequency + 20-kHz offset (S-band).

(c) Test 3: S/C RCVR best-lock frequency - 20-kHz offset (S-band).

(3) Ranging channel delay. This test determined the time delay due to the entire spacecraft ranging channel. The test was made only on a complete assembled spacecraft. Specified spacecraft exciter/TWTA modes and possible antenna configurations were measured.

c. Test results. Compatibility test results are presented below. Tests were run intermittently beginning on July 10, 1970, and ending on Sept. 3, 1970.

MM '71 PTM spacecraft CTA 21 compatibility test. Results of this test were as follows:

(1) No TCP telemetry software was available throughout the tests, thus preventing telemetry readout of certain spacecraft parameters (AGC, SPE, command lock, etc.). This information is necessary when setting signal levels or attempting to acquire two way, etc. Lack of telemetry data required CTA 21 to contact the spacecraft test team to obtain the necessary information. This procedure was awkward at best since it interrupted the normal test procedure operation and although the spacecraft test team was very cooperative they were not fully aware of CTA 21 needs. In lieu of the TCP operational software, the MM '71 SSA/BDA demonstration test software was used and although BER tests were run with satisfactory results, some reservation must be made on the acceptability of the BER data pending a proven performance of the MM '71 Operational TCP hardware/software system.

(2) As in the telemetry software, no TCP command software was available for the entire compatibility test period. When the spacecraft was in the environmental chamber it was necessary to transfer the RF uplink to the spacecraft OSE for command purposes. This was more a nuisance than a problem, in that, again, the test operations would be interrupted with the attendant loss of time. When the spacecraft was in the SAF, transfer of RF link was not required as commands were sent via hardline.

(3) In the planning stages it had been assumed that during compatibility testing the spacecraft would be entirely devoted to compatibility testing, or, at a minimum, the spacecraft would be in a quiescient state where other spacecraft tests would not affect compatibility testing. This assumption proved false chiefly because of the total spacecraft system test time and facility restriction; this required, for the most part, compatibility testing to be done in parallel with other spacecraft testing--resulting, naturally, in a conflict in the desired spacecraft mode or configuration. The major consequence was an inefficient utilization of compatibility test time because of changes, in real time, of planned tests, modes, etc.

(4) The fourth assumption that RF and TLM modes would be selectable by CTA 21 as required for compatibility tests was not possible because of (1) the conflicting configuration requirements as required by other spacecraft tests and (2) lack of TCP operational command software, as discussed above.

(5) The compatibility test software developed for compatibility testing did not fully meet the needs of the test program. It was necessary to reject test data on more than one occasion because of the ambiguous and erroneous data as furnished by the test programs. The time consumed to make a certain measurement using the test software was excessive in a few instances. Also, the test hardware developed for compatibility testing appeared to have a higher than normal malfunction rate. The result was a considerable loss of time, with some data left in question.

(6) The phase jitter data does not meet the test criteria. There are two reasons for waiving the test criteria requirement for the time being. There is no valid method of determining the true phase jitter in the DSIF receiver/exciter reference, and, therefore, no way of knowing the actual phase jitter of the spacecraft receiver and transmitter. A method is being developed that, hopefully, will measure and separate the reference phase jitter. Secondly, the effect of excessive phase jitter would degrade system performance such as threshold and BER checks. No degradation was noted in these areas.

(7) The ranging data obtained during the tests is, at this time, in question. There were problems both with the DSIF hardware and the test software that required real-time changes in the test procedure. Also, the overall ranging and calibration configurations are being investigated. The range data question is yet to be resolved.

(8) The major problem (and a potentially serious incompatibility) was uncovered during BER tests. There is a valid spacecraft mode wherein, during transmission of the low-rate 50-bits/s science data, most of the science instruments are turned off and only DAS engineering data is on. This results in a long string of zeroes with only about 10% bit transitions. The SSA could not maintain symbol sync because of the transition density. In order for the SSA to achieve and maintain symbol sync using the MM '71 demonstration software, the operator must select the wideband filter in the SSA tracking loop during the TCP program initialization.

It was revealed that two areas needed further investigation. First, certain analysis information was needed at that time from the vendor regarding the operational characteristics and capabilities of the SSA. Although there was no specification, it was a design goal to require 30% bit transitions in the data stream to maintain lock. This analysis information included operating bandwidth requirements versus bit transition density and signal level. Second, there was a need to demonstrate the operation of the MM '71 TCP operational mission software with the 50-bits/s science data. There was a possibility that the above demonstration might include the forcing of an SSA operating bandwidth change without a TCP program initialization, meaning loss of data.

This problem is similar to the low transition data stream found in the MM '69 engineering mode. To correct this for MM '71, the engineering data stream was "exclusive-<u>or</u>'d" with a one-zero pattern so that a sufficient number of transition would result. The "exclusive <u>or</u>" fix was not incorporated in the 50-bits/s data.

(9) During the spectrum analysis test, while receiving real time 16.2-kilobits/s data, the analysis data showed spectral components at 2.7-kHz intervals throughout the spectrum ±270 kHz about the RF carrier. The level of the 2.7-kHz component varied from a high of about 14 dB below the carrier to 35.40 dB below the carrier. The majority of these components were in the order of 25 - 30 dB below the carrier. Subsequent BER checks showed no degradation from the predicted value with the 2.7-kHz components present. Investigation will continue.

<u>MM '71 Flight I spacecraft/CTA 21 compatibility test</u>. These tests were run in two parts. The first part was run on Dec. 14-17, 1970; the second, on Feb. 8-10, 1971. Results were as follows:

(1) Downlink threshold one-way RF 29 TLM 26. This test was not performed because the spacecraft was prohibited from the science modes (TLM 26).

(2) Downlink threshold one-way RF 49 TLM 4. This test was performed successfully and met the criteria.

(3) Uplink threshold RF 32 TLM 4. This test was performed successfully and met the criteria.

(4) Spacecraft receiver pull-in range, tuning range, and rate. This test was performed with the criteria being met on the tuning range and rate portion of the test. However, the spacecraft pull-in portion of the test failed during steps 10 through 13 (spacecraft receiver failed to acquire in <60 s with a 200-Hz (S-band) offset from best lock frequency with a signal level of -142 dBmW uplink. Steps 15 through 19 of this test were cancelled because of the problem above.

(5) Uplink spectrum analysis. This test was performed successfully. Spectrum photographs were taken in all modes and a cursory check of these photographs showed no anomalies.

(6) Downlink spectrum analysis RF 18 TLM 22. This test was performed successfully. A spectrum photograph was taken and an analog recording was made of the telemetry data. A cursory check of the photograph showed no anomalies, and the analog recording was sent to DSS 71 for post-test analysis.

(7) Downlink spectrum analysis RF 62 TLM 6. This test was not performed because the spacecraft was prohibited from the science modes (TLM mode 6).

(8) This test was performed; however, the test criteria, as written, were not met. This was a question for investigation by DSIF operations, since it was believed that the spacecraft transponder as designed would never pass this procedure as written. It is not suggested that this procedure be modified for other projects; however, a special test procedure was recommended for MM '71.

(9) Auxiliary oscillator frequency measurement RF 29 TLM 4. This test was performed successfully and met the criteria.

(10) Auxiliary oscillator frequency measurement RF 49 TLM 4. This test was performed successfully and met the criteria.

(11) Command sync acquisition. This test was performed successfully and met the criteria. The S/C command detector achieved lock in <8.5 min at all frequency offsets and signal levels specified.

(12) Command polarity verification. This test was performed successfully and the polarity of the ground/flight command system was verified as correct.

(13) Transmitter phase jitter. The peak phase jitter measurements exceeded the RFS specification. This test is not considered a valid test since there is no way to separate the DSIF receiver noise from the spacecraft noise. Large peaks (>20 deg) would lead to investigations to determine the source, but the levels observed are considered reasonable.

The RMS phase jitter measurement, which uses a cross correlation technique to derive only spacecraft phase jitter, is considered the more valid test, and is used as the prime measure of spacecraft performance.

(14) TLM performance, four-channel. One of the processing channels was generally not working during these tests. The problem was traced to faulty wires in a patchboard at CTA 21. The problem would cause either one or both of the TLM channels obtained from the Telecommunications Developmental Laboratory, simulating the second spacecraft, to be nonoperational. Post-test investigation found the patch problem, and proper operation was restored. The patch configuration is correct, but two patch cords were faulty.

MM '71 Flight II spacecraft/CTA 21 compatibility test. These tests were performed on Feb. 24-26, 1971. All tests listed under "Test definitions and objectives" above were conducted. Failure to meet the criteria is not necessarily a spacecraft or CTA 21 problem, but may be due to a criteria or test configuration problem. The failures are discussed below with justification for accepting the observed performance. Results were as follows:

(1) Transmitter phase jitter. Peak phase jitter in this mode exceeded the test criteria. However, no technique has been devised to identify whether the peaks observed are due to the spacecraft or the DSIF. Large peaks (>20 deg) would be considered a problem and the source located. The observed test levels are not considered problems.

The RMS phase jitter measurement uses a cross correlation technique to identify only the phase jitter due to the transmitter and is considered the more valid measure of transponder performance.

(2) TLM processing. Measured ST/N_0 for the 8-1/3-bits/s engineering was 0.11 dB outside test limits. The ST/N_0 was better than expected. This is not considered a problem.

(3) Four-channel TLM processing. The ST/N_0 of the 8-1/3-bits/s channel for the TLM signal provided by the Telecommunications Developmental Laboratory (TDL) was 3.36 dB lower than predicted. The source of the problem is felt to be related to the TDL/CTA 21 interface and not a spacecraft problem. A PFR was written.

(4) Command operational capability. Three problems occurred during the Flight II testing; all are considered to be CTA 21 internal problems:

(a) During test 15, DC-8 aborted at 17:17:40, 2/25/71 GMT. DC-8 was reloaded and transmitted successfully. The abort was a 00001.01. This was a problem that needed to be investigated further.

(b) During test 33, DC-9 aborted at 22:22:31, 2/25/71 GMT. DC-9 was merely retransmitted and completed successfully. The abort was a 00001.01. This was a problem that needed to be investigated further.

(c) During test 22, the TCP was reloaded inadvertently, with command modulation ON. This caused the spacecraft to drop command detector lock. This is an operational constraint and should be included in all operational procedures.

A PFR was written covering items (a) and (b) above.

MM '71 Flight I spacecraft/DSS '71 compatibility test. These tests were performed on Mar. 24-26, 1971. All tests listed under "Test definitions and objectives" above were conducted. Failure to meet the criteria is not necessarily a spacecraft or DSS 71 problem, but may be due to a criteria or test configuration problem. Two problems which occurred during the Flight I testing, are considered to be DSS 71 internal problems:

(1) During Test No. 2, a DC-25 aborted at 150735 GMT on Mar. 24, 1971. The abort was caused by "Bit Rate Out of Limits."

(2) During Test No. 2, a DC-26 aborted at 151314 GMT on Mar. 24, 1971. The abort was caused by a 00001.01 "Bit by Bit Verification Failure."

A spacecraft PFR and a DSIF DR were written.

d. Problems and recommended solutions. Problems and solutions are discussed below.

RF tests. The following anomaly occurred:

(1) Anomaly

Spacecraft "best lock" frequency tests at CTA 21 and DSS 71 on flight spacecraft revealed that procedures utilized during Mariner '69 were inadequate for determining uplink acquisition frequency.

Solution

"Best uplink sweep" procedures were developed and documented and were utilized successfully during MM '71 tests and training.

Telemetry tests. The following problem occurred:

(1) Problem

During the dual-carrier/multiple-subcarrier tests at CTA 21 utilizing the Flight II spacecraft and a breadboard model at TDL, the ST/N_0 of the 8 1/3-bits/s data was 3.36 dB lower than predicted.

Solution

This problem was unresolved. However, tests were planned at CTA 21 utilizing RF sources at SAF and TDL. The dual-carrier/multiple-subcarrier operation was not required until planet encounter.

Command tests. The following problems occurred:

(1) Problem

During the preparation for Flight I compatibility tests at CTA 21, it was noted that commands would always abort if command modulation and ranging modulation were ON simultaneously.

Solution

An investigation of this problem revealed that the confirmation detection was not compatible with command and ranging modulation ON simultaneously. The operational program was modified to disable the confirmation detector.

(2) Problem

During the MOS/spacecraft (Flight I) compatibility tests performed in February 1971 and supported by CTA 21, the spacecraft command detector momentarily dropped lock on several commands.

Solution

This problem was investigated and found to be a software problem. The operational program was incorrectly reloading the F_0 command register at the beginning of each command. The program was modified to load this register during the initialization only.

(3) Problem

During the Flight II spacecraft command compatibility tests at CTA 21, two command aborts occurred. In each case, the abort reason was a "bit-by-bit" verification failure.

Solution

This problem was investigated and concluded to be a noisy channel in $F_s/2F_s$ comparison circuitry. The command modulation assembly (CMA) tolerance on this measurement was modified from 1 μs to 5 μs.

(4) Problem

Several command "bit-verify" aborts occurred during spacecraft DSIF compatibility tests.

Solution

Intensive troubleshooting revealed that the problem was an inherent CMA design fault and was isolated to noisy CMA input lines. Engineering Change Order 71-087 involving incorporation of noise suppression diodes and capacitors in each of the 48 lines involved, rectified the problem. 10,000 commands were transmitted from the modified CMAs at CTA 21 during a "proof soak" test without any alarms or aborts, plus 7,000 commands from DSS 14.

(5) Problem

The spacecraft command system apparently dropped phaselock for 51 s during the Flight II/DSS 71 test on March 29, 1971.

Solution

This was not a DSS problem, as the spacecraft had experienced the same phenomenon using ground support equipment.

Ranging tests. The following anomaly occurred:

(1) Anomaly

Compatibility tests at both CTA 21 and DSS 71 with Flight II spacecraft revealed the ranging acquisition threshold was degraded by 1 to 1.5 dB from that predicted. The Flight I spacecraft was at the predicted ranging threshold.

Solution

No solution was required, as tolerance of this measurement is ±2 dB.

Operations. The following anomaly occurred:

(1) Anomaly

During compatibility tests with the Flight II spacecraft at CTA 21, the TCP operational program was reloaded during the investigation of a telemetry problem. This operation caused the spacecraft command detector to drop lock. This is an operational constraint.

Solution

All applicable operational procedures included the removal of "Command Modulation" from the exciter prior to reloading the TCP operational program.

2. DSIF training and tests. DSIF training and tests are described below.

a. Introduction. An abbreviated description of DSIF operations activities in preparation for, and up to and including launch of Mariner 8 and 9, is presented in this section. New DSIF equipment is covered briefly, with rather more detailed coverage of the DSIF training, testing, operational documentation, and performance aspects of the preparations.

A direct result of the application of knowledge and experience accumulated by the DSIF during preparations for the now considerable number of past lunar and deep space missions has been the development of a logical standard pattern and sequence of events. Basically, the major events in readying the DSIF for a mission are as follows:

(1) Evaluation of new mission spacecraft parameters and possible requirements for new DSIF hardware and software.

(2) Design, prototype fabrication and checkout of necessary additional new hardware.

(3) Design of new software.

(4) Procurement of production models of hardware including spares, documentation, etc.

(5) Generation of engineering (mission-independent) training program, initially for DSIF instructors, then DSS personnel.

(6) Generation of operations (mission-dependent) training plan (DSN Test Plan, Vol. VI).

(7) Generation of operations (mission-dependent) procedures (DSN Operations Plan, Vol. VII).

(8) Acceptance testing of computer software.

(9) Implementation of any necessary mission-independent DSS personnel training.

(10) Implementation of mission-dependent DSS personnel operational training (if possible with live spacecraft).

(11) Installation of hardware at DSSs (according to DSN Operations Plan, Vol. VI, DSIF Configuration Document).

(12) Delivery of software to DSSs and implementation of hardware and software integration tests at DSSs (DSN Test Plan, Vol. VI).

(13) Implementation of DSS on-site training.

(14) Starting DSIF operational verification tests.

(15) Supporting DSN system tests.

(16) Finalizing DSIF OVTs.

(17) Supporting DSN OVTs.

(18) Supporting MOS testing.

(19) Supporting launch and mission.

MM '71 preparations followed this outline as closely as possible, but slippages in delivery of hardware, software, and documentation, and in particular, loss of SFOF support, seriously restricted the early DSIF training, making numerous tradeoffs necessary.

b. New DSIF equipment for MM '71. The MM '71 mission design called for increased capabilities at the DSSs, the main requirements being to process four spacecraft subcarriers (one engineering and one science from each of two spacecraft) simultaneously the science data at up to 2 kilobits/s at the 26-m stations and up to 16.2 kilobits/s at DSS 14), higher command activity, and repetitive occultation experiments.

These added requirements, plus the continuing state-of-the-art improvements, resulted in the following new equipment being installed before MM '71 launch:

(1) Open-loop receivers and peripheral equipment (at DSSs 14, 41, and 62).

(2) Additional SDAs (a total of four each at DSS 12, 41, and 62 and six at DSS 14).

(3) Command modulator assemblies.

(4) New TCP HSDL buffers (for use with 4800-bits/s modems).

(5) Dual high-density digital recorders (DSS 14 and 71 and CTA 21).

(6) Dual low-density digital recorders (DSS 12 and 41 and 62).

(7) Symbol sync assemblies (SSAs).

(8) Block decoder assemblies (BDAs).

(9) Simulation conversion assemblies (SCAs).

(10) DSIF monitor system, Phase 1 (hardware and software).

(11) Updated station monitor console (SMC).

(12) Updated timing system (DSIF Frequency and Timing Subsystem II).

(13) Dual Block III masers.

The foregoing equipment was installed and, with the exception of the open-loop receivers, was operational before launch. The open-loop receivers were operational at the end of June 1971.

c. Mission-independent training. Formal training for two engineers from each DSS was carried out during August 1970. This training covered detailed theory of operation, calibration, maintenance, and general operation of most of the equipments listed in Subsection b. above. After completing the course, the engineers returned to their stations with training packages and proceeded to instruct the station personnel on the operation and maintenance of the equipment in their areas of concern.

At this time the new equipment was delivered and installation started at the prime MM '71 stations: DSS 12, 14, 41, 51, 62, 71, and MSFN ACN.

d. Mission-dependent training. The mission-dependent training took place at JPL and the Goldstone Deep Space Communications Complex during November and early December 1970. The trainees were as follows: one operations supervisor, one senior RF operator, and two senior digital instrumentation operators from each of the MM '71 prime stations, plus the DSIF elements of the DSN Operations Control Team, i.e., five assistant DSIF chiefs and five station controllers. Approximately six engineers from the DSIF Operations Section also took part in the training to varying degrees.

The purpose of this training was as follows:

(1) Train operators in the use of MM '71 software and the recently updated hardware under realistic operational conditions.

(2) Familiarize operators with MM '71 spacecraft RF parameters.

(3) Check, verify, and finalize MM '71 operational procedures with teams of DSS operators.

(4) Develop and exercise any special procedures required to work around spacecraft nonstandard performance or spacecraft/DSIF design incompatibilities.

(5) Ensure immediate recognition and isolation of any inadvertent simulation-induced problems during DSIF/DSN/MOS tests.

(6) Familiarize members of the DSN operations organization, including the Operations Control Team, with pertinent aspects of the above.

In general, the training consisted of lectures, classroom instruction, review of procedures, hands-on equipment familiarization, practice of procedures, observation, and tours of facilities. A list of the speakers of the training lectures at JPL is contained in Table 36 which also lists their subjects. The classroom instruction, for operators only, consisted of familiarization with the SCA and TCP software programs and was integrated with hands-on training on the computers. This phase, conducted at the Goldstone Network Training Support Facility and the DSS 12 control room, lasted 4 days.

While the operators were at Goldstone, the supervisors were reviewing two volumes of the DSN Operations Plan for MM '71--Vol. VI: DSIF Station Configuration for MM '71, and Vol. VII: DSIF Operating Procedures, as well as Vol. VII of the DSIF Test Procedures. Tours of the Spacecraft Assembly Facility (SAF) and the SFOF were conducted. Station countdowns on the Multiple-Mission Telemetry and Command Subsystems at DSS 12 occupied 3 days.

The final 12 days of training were conducted at the CTA 21. Both a live MM '71 spacecraft and the SIMCEN in the SFOF were used as data sources. The trainees operated station equipment in accordance with MM '71 Operating Procedures and DSIF Standard Operating Procedures and daily sequence of events. This phase was conducted on a team, or crew, basis; teams not involved in counting down the station or tracking periods observed activities at CTA 21 or in the SFOF.

On Nov. 5, 1970, operator trainees attended classroom instruction on the SCA and TCP software programs. Each student received approximately 3 1/2 hours on each program.

On Nov. 6-8, 1970, on-site SCA and TCP training was held in the control room at DSS 12. All individuals received 4 hours of group training on the SCA mnemonic inputs. Eight hours were spent using the SCA as a data source for the TCP, with the students configuring the SCA, RCVR, SDAs, SSAs, BDAs, and CMAs, as if in an actual countdown. All individuals received 12 hours training on the TCP/CMA software covering the telemetry and command portions of the program. A major problem area was in the command portion of the software. The software and documentation were incorrect, and certain interrupt patches were omitted.

For the station countdown on Nov. 11-13, 1970, all operator trainees plus the operation supervisor of the stations participated in the countdown tests. The group from each station had the opportunity to do each countdown twice for a total of 6 hours actual hands-on practice. Included in the training was 2 hours theory on Y factor techniques. Participating students were given an introduction to the CC-30 display system by video tape. Then a brief explanation was given on how the monitor program interfaces with the SMC/CRT, followed by a demonstration program from the DIS. In addition, convergence of the CC-30 color TV display was taught by hands-on training. The summary was presented by video tape.

Training was conducted at CTA 21 from Nov. 16 through Dec. 2, 1970, in three phases, using equipment configurations as follows:

Nov. 16-21	CTA 21/spacecraft at SAF/SFOF
Nov. 23-25	CTA 21/SIMCEN/spacecraft at SAF/SFOF OPS Control

Nov. 30 – Dec. 2	CTA 21/SIMCEN/SFOF OPS Control; CTA 21/SIMCEN

A final critique covering DSIF operator training for MM '71 was held on Dec. 3, 1970.

A typical sequence of events was used from Nov. 16-30. Minor modifications were made from time to time to facilitate changes in configuration. This sequence simulated a normal spacecraft pass with the following nominal schedule of activities:

0800-1100 PST	Station countdown
1100-1700 PST	Tracking
1700-1800 PST	Daily critique

As a result of the daily critiques, training activities during Dec. 1 and 2 concentrated on hands-on operation of the SCA only. Each team was allotted 2 hours to operate the SCA in the stand-alone mode and as a data router in the SIMCEN long-loop mode. The trainees returned to their DSSs the second week in December 1970 and, using the training packages provided, initiated the DSS on-site training programs. Two weeks were allotted to on-site training, and the DSIF operational verification tests started on Jan. 1, 1971.

e. On-site training. The operator "on-site" training consisted of classroom instruction and training exercises conducted at each station for the station staff. It included "in house" operational tests designed by the station director to exercise the station in the MM '71 configuration.

All "on-site" operator training carried out at a DSS was the direct responsibility of the station director, who was the Training Controller for the "in-house" training at his station. The DSIF training program was based on the assumption that the limited number of operators trained at Goldstone and CTA 21 were to train the other operators at their respective stations.

The objective of this training was to ensure that all DSS operational personnel were adequately trained to support the MM '71 prelaunch and mission activities.

Trained DSS personnel were supplied with a training package by the DSIF Training Unit Supervisor. Formal "classroom" sessions similar to the Goldstone training were conducted until all the shift operators concerned were completely familiar with the hardware and software in their area.

f. DSIF operational verification tests. The DSIF operational verification tests (OVTs) verified the compatibility of the MM '71 operating procedures, equipment, and operational interfaces. In addition, they demonstrated that DSIF operational personnel were adequately trained, and at the same time provided valuable additional training.

During simulated tracking operations, DSIF operating procedures were exercised by the normal shift complements of personnel in DSIF Control and at the DSS in accordance with the SOE message provided prior to each test. These messages consisted of detailed sequences simulating various phases of the mission.

The initial OVT with each DSS was directed mainly toward familiarization in the use of the SCA.

Subsequent OVTs followed sequences simulating tracking of a single spacecraft during cruise, launch, trajectory correction maneuver, and two spacecraft returning engineering and science telemetry data. All OVTs exercised the MMC System in the standard automatic HSD mode and thoroughly exercised the TTY backup telemetry and emergency command (manual entry) operational procedures. Random unscheduled emergency command exercises were injected into the OVT in real time during later tests.

Table 37 summarizes the number of operational tests supported by the various stations.

g. Operational performance of new equipment. The new equipment performed very satisfactorily under operational conditions during OVTs, both launches, one trajectory correction maneuver, and approximately 4 weeks of tracking.

The main exception was the operation of the Command System. In the early training and testing, numerous command alarms and aborts were experienced. These were gradually eliminated by modifications (patches) to the DSIF TCP and SFOF 360/75 software programs and eventually reissue of both programs. However, approximately 6 weeks before launch, it became apparent that a bit-verify alarm/abort problem still existed. This triggered an intensive 24-hour day troubleshooting exercise at Goldstone, CTA 21, and some of the overseas stations. The problem was isolated to noise inherent in the TCP/CMA basic hardware design. A modification was hastily fabricated and rushed to the prime MM '71 stations, installed, and soak tests carried out before the ORT.

During the extensive soak tests, a specific version of the bit-verify abort problem (abort on first bit of first command in block) was observed on a random/periodic basis. This was isolated to a software-induced hardware (timing) problem where an erroneous bit-verify abort could occur because of the phase relationship between the DSS 1-pulse/s timing and the CMA command modulation frequency (random) coupled with the cumulative effect of the phase difference (periodic). A software program fix was generated. However, due to the lack of time to carry out extended checks on the fix before launch, it was decided that any unknown side effect of the fix would be a greater risk than the known possibility of an erroneous command abort, and the fix was not incorporated for launch and trajectory correction. Both launches and the first trajectory correction maneuver were supported without any command problems.

3. GCF Tests. The GCF testing is described below.

a. GCF system testing. As explained earlier, existing capability within voice and TTY systems were employed without an overall systems test in support of MM '71. The

mission-independent application of WBDS was tested in November and December 1970.

Actual facility tests carried out before launch consisted only of those tests performed in association with the high-speed system (HSS) upgrade. The following paragraphs therefore relate only to the HSS.

Separate tests were conducted between each DSS and the SFOF, and, in each case, the test series was extended when anomalies were encountered. Beginning in October 1970, the stations were tested in the following order: DSS 12, 41, 51, 62, 71, CTA 21, SIMCEN, DSS 14, and 42.

It was originally intended to use a special software test program which would exercise the interfaces between the GCF and DSIF and between the GCF and SFOF, in addition to providing performance data on all installed equipment and operational circuits. However, unforeseen delays in the test program development and problems with the availability of machine time required that an alternate test sequence be developed. This enabled all GCF equipment, procedures, and circuits up to the DSIF interface to be checked out. A separate test series validated the interface at the SFOF.

A number of discrepancies were discovered and rectified before acceptable all-around performance was obtained. Among the most notable of the discrepancies were:

(1) A severe impulse noise cross talk into Australian circuits between DSS 41 and the Canberra Switching Center causing high error rates. This was subsequently cleared by the common carrier, after being found to be in Woomera Village. High-level dialing pulses were the prime cause of the problem.

(2) Early high error rate from DSS 51 was due to the lack of regeneration capability at Ascension Island NASCOM Test and Patch Facility. The error rate was improved into acceptable limits after regeneration became operational at Ascension.

(3) Line level problems at Madrid Switching Center and DSS 62 delayed final acceptance test.

(4) In-house equipment installation delays at DSS 71 caused schedule slippage.

Other minor equipment discrepancies were also revealed at various locations, and certain items of test equipment were found to be inadequate for the required tests. All such items were restored to full operational condition.

The operational activation and use procedures were adjusted as a result of this test series and the extent of all personnel training was determined to have been sufficient.

Generally speaking, more than 99 percent of all transmitted data blocks (each block is 1200 bits) was received without error.

b. GCF operational verification tests. The purpose of OVTs conducted before launch was threefold:

(1) Verify operational communication configurations and procedures required of the GCF to support DSN/MM '71 MOS testing and subsequent launch and cruise flight operations.

(2) Verify operational integrity of NEP mission-dependent GCF interfaces at SFOF and Cape Kennedy.

(3) Verify GCF procedural interfaces with supporting non-DSN agencies (e.g., NASCOM and MSFN) and the DSN Operations Control Team.

A series of at least three OVTs was conducted with each of the prime stations supporting MM '71 before launch. Supporting elements of the MSFN were also tested.

No major procedural deficiencies were uncovered during the prelaunch series of OVT. Minor procedural incidents encountered were attributed to the nature of simulated anomalies presented by the OVT test supervisor in the test SOE. All such incidents were quickly resolved with no adverse effect.

4. SFOF tests. Since the SFOF Mark IIIA Data System was an entirely new implementation for MM '71, a broad spectrum of testing was required to verify design implementation. The framework for facility testing was outlined and described in the SFOF Implementation Plan. This document outlined the progression of tests, assigned responsibilities, and identified the required control documents. It further served to identify points in the development process where capabilities were transferred from the development to the operations organization. The Implementation Plan established the Data System Integration Plan for Mark IIIA and Mark IIIB and provided for a phased implementation with several models of the data system to be tested and delivered. Mariner 9 launch was supported by the Model 2 SFOF Data System.

a. Equipment checkout tests. The first major test milestone was the completion of equipment checkout of the Model 1 equipment configuration. The purpose of this test was to verify the equipment and the data paths supporting various areas within the SFOF. Specifically, this test checked the following equipment data paths:

(1) CPS to user areas and user areas to CPS.

(2) CPS to Communications Processor and Communications Processor to CPS.

(3) HSD paths to and from the CPS.

This test was used to diagnostic monitor (Diamon) a software package that was adopted from the Alert System developed at the Manned Spacecraft Center, Houston, Texas. This test was developed and conducted by the SFOF/GCF Development Section and was conducted on Oct. 23, 1970.

b. Subsystem tests. Each of the SFOF software subsystems was extensively tested. Subsystem Engineers were aided in this effort by the *Facility System Engineers and the Cognizant User* Engineers. The SFOF software subsystems are as follows:

(1) Master Control and User Interface Subsystem (MCUIS).

(2) Telemetry Subsystem.

(3) Command Subsystem.

(4) Tracking Subsystem.

(5) Monitor and Operations Control Subsystem.

Testing at the subsystem level verified basic software capabilities as the subsystem operated in a controlled environment. In addition to their prime function of verifying subsystem performance, the subsystem acceptance tests provided additional verification of CPS and MCUIS equipment and software capabilities at facility level. They thus provide a natural transition into the system integration testing. The Model 1 software subsystems tests were completed and accepted for integration as follows:

Subsystem	1970
Telemetry	Oct. 23
Command	Nov. 2
Tracking	Dec. 1
Monitor and Operations Control	Nov. 2

c. Integration tests. This test phase is the responsibility of the Data System Integration Manager. The three major areas in this effort are described in detail in the Data System Integration Plan. Basically the three areas are as follows:

(1) Acceptance for integration.

(2) Computer system interface verification.

(3) Computer system user program integration.

This very important test phase established compatibility between the software subsystems and the operating system. The subsystems were tested in an environment resembling the intended operational environment. Extensive use was made of special software for monitoring performance and gathering statistics on module performance. Priorities within the computer were altered, and the integrated software was tuned for optimum performance in the real-time environment. The Model 1 integration was completed by Dec. 10, 1970, except for portions of the tracking subsystem.

d. SFOF system tests. The primary purpose of the individual SFOF system-level tests was to demonstrate that the implementation of a *design satisfying functional requirements and capabilities* had been successfully completed on a per-model basis. The test further provided a means for transferring developed systems to the SFOF/GCF Operations Section. These tests included *the implementation effort by demonstrating* the effective integration of equipment, systems software (MCUIS), applications software, and operations personnel. After the successful demonstration of the performance specified in the acceptance criteria for each test, the SFOF and software systems were transferred to the control of SFOF/GCF Operations Section. The facility system tests are the responsibility of the Facility System Engineer for the specific system. The SFOF systems were as follows:

(1) SFOF Command System.

(2) SFOF Telemetry System.

(3) SFOF Monitor and Operations Control System.

(4) SFOF Tracking System.

Test plans for each of the systems were documented in the Mark IIIA SFOF Systems and Composite Test Plan. These plans were augmented by procedures and sequences prepared by the System Engineers. SFOF systems tests were conducted on the Model 1 capabilities on Dec. 10 and 15, 1970.

e. SFOF combined systems tests. Overall objective of the combined systems tests was to demonstrate that each model of the SFOF Mark IIIA implementation was ready for transfer of the facility configuration to DSN operations, consistent with capabilities defined for the model. To accomplish this objective, the tests demonstrated that all SFOF systems were capable of concurrently performing required functions in an operational environment. In addition, they provided familiarization and training to DSN Operations and Analysis personnel in the operation of newly developed SFOF software and equipment. The Model 1 combined systems test demonstrated the basic capabilities of the Mark IIIA Model 1 SFOF tracking, telemetry, command, and monitor and operations control systems operating concurrently in a simulated MM '71 launch phase. These combined systems tests were conducted on Dec. 10 and 15, 1970, for Model 1 capabilities. Model 1 support of DSN system testing operations began on Dec. 16, 1970. The SFOF combined system test plan is documented in the Mark IIIA SFOF Systems and Composite Test Plan.

f. Model 1 updates. As a result of DSN testing and improvements in SFOF systems software, several updates were made to the Model 1 software. The final update to Model 1 was released on Mar. 19, 1971, and was identified as model version 40.

g. Model 2 tests. Model 2 testing followed the same progression as Model 1. The first combined system test of Model 2 capabilities was conducted on Feb. 25, 1971. This test was conducted using version 21 of Model 2. On Mar. 23, 1971, the combined system test on version 26.2 resulted in the acceptance and transfer of SFOF Mark IIIA Model 2 data system to DSN Operations. This *major milestone* placed the Model 2 configuration under control of the Configuration Control

Board and subject to the DSN Discrepancy Reporting System. Four updates were approved by the Configuration Control Board before launch of the MM '71 spacecraft. These updates were made in April 1971 as follows:

Apr. 9	Model 2 version 26.4
Apr. 19	Model 2 version 26.5
Apr. 20	Model 2 version 26.6
Apr. 26	Model 2 version 26.7

Version 26.7 was the launch system for Mariner 9 on May 29, 1971.

h. Facility operations tests. Facility operations tests were restricted to those tests designed to train SFOF operators in CPS recovery operations. The procedures and exercises were designed and conducted by the MM '71 Data System Project Engineer. These tests were conducted on three shifts to train key people for all shifts.

SFOF operational verification tests as such were not conducted, primarily because of the long involvement of operations personnel in the development process. Furthermore, SFOF operators were required to support with the Mark IIIA data system all other facility OVTs of the DSN, thus providing hundreds of hours of participation in simulated MM '71 operations.

i. Facility configuration verification test. This test was conducted as a prelaunch verification test starting at Launch - 24 h and ending at Launch - 6 h. CPS operators and controllers conducted the test under the supervision of the Computer Operations Chief. The facility configuration verification test was designed to verify equipment and data paths to all user terminal and display equipment and to test all computer interfaces. Extensive use was made of diagnostic software and checkoff sheets for verification of proper operation of all equipment in the launch configuration.

j. Miscellaneous facility tests. The Mark IIIA data system was used approximately 12 times during the period mid-November 1970 through mid-January 1971 to verify proper operation of the MSFN software to be used to support the near-Earth phase. These tests were conducted by the SFOF Data System Project Engineer for MM '71. The tests were conducted at a time shared with development tests, using the limited display capabilities of Model 1.

5. Network systems tests. A total of 13 deep space phase DSN MM '71 system and combined systems tests were conducted before launch to prepare the DSN for support of MM '71 launch. See Table 38 for these 13 tests for deep space phase, plus two tests for near-Earth phase, conducted over the period from Dec. 16, 1970, through Apr. 23, 1971.

As new 360/75 operational software capabilities were added, system and combined systems level tests were repeated. Certification and acceptance of operational 360/75 launch software and subsequent release dates are indicated below, both for the operating system (JPLOS) and mission software.

DSN system tests verified integrity of end-to-end data flow (generation, routing, and processing) with each DSN system and the capability of the system to support MM '71. Successful completion of all facility integration tests was a prerequisite for each DSN system test.

DSN combined systems tests verified integrity of end-to-end data flow of all DSN systems operating simultaneously and thereby demonstrated DSN capability to support MM '71 and interface with MM '71 equipment and software. Combined system and performance demonstrations verified the ground data system under maximum loading conditions in all modes of operation. Successful completion of DSN systems-level tests were a prerequisite to the combined systems tests.

Resources required for the DSN system tests and DSN combined systems tests were as follows:

(1) Test Supervisor: DSN PE/respective DSN System Engineers.

(2) Test Conductor: DSN Operations Chief.

(3) Support personnel: Appropriate DSIF, GCF, SFOF and personnel and respective DSN system personnel responsive to the Test Conductor.

(4) Area: SFOF user area with appropriate I/O devices operational.

(5) Duration: 8 hours per test.

Data sources for the DSN system tests and DSN combined systems tests were as follows:

(1) Telemetry: Simulated telemetry data from the SIMCEN.

(2) Command: Simulated command data.

(3) Tracking: Simulated tracking data from the Tracking Data Handling Subsystem or SIMCEN.

(4) Operations Control: Simulated MM '71 telemetry, command, and tracking data from SIMCEN.

(5) Simulation: 6050/1108 software.

(6) Combined Systems: Simulated data from SIMCEN.

Test profiles and acceptance criteria were as follows:

(1) Telemetry System test profile:

Simulated telemetry data injected into selected tracking stations.

Data formatted for HSD or TTY transmission via GCF to SFOF.

HSD processed by 360/75 and displayed on SFOF output devices.

HSD also to be available to the Mission Test Computer and the Project Green Box.

Data to include error and limiting case conditions.

COMGEN to present a Central Computer and Sequencer memory to the Telemetry System for comparison with a spacecraft memory dump.

(2) Telemetry System test acceptance criteria:

Satisfactory performance of capabilities described in Volume III of DSN Operations Plan for MM '71.

Satisfying interfaces described in Volume II, Part B, same plan.

(3) Command System test profile:

Command data to be generated by the 360/75 using COMGEN and manual input transmitted to tracking stations via HSD.

Data to be received and processed at the Telemetry and Command Processor at the stations.

All command input modes (including DSS manual), verification loops, enable/disable, confirm, abort functions to be verified.

System capability to reject erroneous data and configurations to be verified.

(4) Command System test acceptance criteria:

Successful generation and transmission of all command data.

Submission of resulting Command System test data as evidence of successful transmission.

Satisfying capabilities and interfaces described in Volume II, Part B, and Volume III of the DSN Operation Plan for MM '71.

(5) Tracking System test profile:

Data to be routed from DSIF TDH in real time, via GCF, to 360/75 for real-time processing.

Data then routed to the orbital data editor in 1108.

Ephemeris to be generated in 1108 by the double-precision trajectory program and transmitted to 360/75.

(6) Tracking System test acceptance criteria:

Same as for Telemetry System above.

(7) Operations Control System test profile:

Operations Control System functions, as the mechanism for directing operation of DSN facilities and systems, are tested when Telemetry, Command, and Tracking Systems are tested.

(8) Operations Control System test acceptance criteria:

Effective operations control while executing test sequences and successful demonstration of operations control support functions as they pertain to MM '71.

(9) Simulation System test profile:

SIMCEN to generate and output MM '71 telemetry and command data in HSD blocks and tracking data on TTY.

Demonstrate successful control of program operation and data control.

(10) Simulation System test acceptance:

Successful demonstration of ground data system committed capabilities

Problem summaries of DSN systems and combined systems tests by the date tests were run are given in Tables 39-47. Deficiencies are listed by systems.

6. <u>MOS/TDS operational readiness tests</u>. DSN supported two MM '71/MOS-TDS operational readiness tests: (a) April 29-30, 1971, for spacecraft H, and (b) May 18, 1971, for spacecraft I. Objectives of the tests were to exercise all systems dedicated to support each spacecraft launch and to verify readiness. Test acceptance criteria were that all dedicated systems demonstrate readiness during such exercises.

Test objectives were satisfied; mission operations personnel and all systems demonstrated a high degree of readiness during each ORT.

Both tests began at 1500 PDT, representing spacecraft H launch date of Day 128 (May 8, 1971) and spacecraft I launch date of May 16, 1971 (Day 136), and identical time before-launch of L - 1 h, 54 min. In both tests, the countdown proceeded smoothly and entered a built-in hold, T - 10 min, at 1629 PDT. A 15-min hold was planned for these exercises to synchronize liftoff with the tracking data package. Countdown proceeded smoothly following the hold to the liftoff as scheduled at 1654 PDT. The test proceeded nominally after liftoff through the plus count until the end of the tests at 2000 PDT.

In both instances, the Simulation System provided excellent support, enhancing successful completion of the tests. Test objectives were satisfied; Mission Operations personnel and all systems demonstrated readiness during each ORT.

7. <u>Project test support</u>. Including the two ORTs, 35 MOS/MM '71 tests were supported by DSN to ensure Project training and readiness. Training exercises and tests were conducted with SFOF, GCF, DSIF, DSS, and SIMCEN. The list of tests is given in Table 48.

Table 32. MM '71 MOS training and tests, personnel participation requirements

	3. MO Prelim Trg: MTC Prelim Capabilities	4.1 MOS Orientation Lecture	4.2 DSN Orientation Lecture	4.3 SFOF Lecture/Tour	4.4 Software Orientation Lecture	4.5 Communications Lecture	4.6 TLM System and Data Flow Lecture	4.7 CMD System and Data Flow Lecture	4.8 Tracking Data System and Data Flow Lecture	4.9 Operations Interface Lecture	4.10 User Equipment and Telem Format Lecture	4.11 MTC Total Capabilities Lecture	5.1 Navigation Team Training	5.2 Spacecraft Team Training	5.4 Command Team Training	6.1 MO/SFOF: H Nominal Cruise Operations	6.2 MO/SFOF: H Nominal Launch Operations	7.1 MO/TDS: TLM and CMD Training	7.2 MO/TDS: H Nominal Trajectory Correc Seq	7.3 MO/TDS: H Nominal Launch	7.4 MO/TDS: I Nominal Launch/H Nom Cruise	7.5 MO/TDS: H Nominal Trajectory Correction	8.1 ODT: H Trajectory Correction	8.2 ODT: I Launch/H Cruise	8.3 ODT: I Trajectory Correction/H Cruise	8.4 ODT: I Launch-Traj Corr-Cruise/H Cruise	8.5 ORT: Launch-Trajectory Correction-Cruise
Project											CANCELLED																
Mission Manager*																							X	X	X	X	X
CMO*		X																		X	X	X	X	X	X	X	X
ACMO		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Simulation Team		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Navigation Team		X	X	X	X	X	X	X	X	X		X	X				X			X	X	X	X	X	X	X	X
Data Processing Team		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Spacecraft Team	X	X	X	X	X	X	X	X	X	X		X		X	X		X		X	X	X	X	X	X	X	X	X
Science Data Team		X	X	X	X	X	X	X	X	X		X															
Science Recommendation Team		X	X	X	X	X	X	X	X	X		X															
Command Team		X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sequence Group		X	X	X	X	X	X	X	X	X		X					X		X	X	X	X	X	X	X	X	X
Log Keeper																X				X	X	X	X	X	X	X	X
TDS																											
DSN																											
Project Engineering Team*		X	X	X	X	X	X	X	X	X		X				X	X		X	X	X	X	X	X	X	X	X
Operations Team		X	X	X	X	X	X	X	X	X		X			X	X	X	X	X	X	X	X	X	X	X	X	X
Simulation Team		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

*Participation in operational exercises required only as normal for the represented mission phase.

Table 33. MM '71 MOS training and tests, resources requirements

	3. MO Prelim Trg: MTC Prelim Capabilities	4.1 MOS Orientation Lecture	4.2 DSN Orientation Lecture	4.3 SFOF Lecture/Tour	4.4 Software Orientation Lecture	4.5 Communications Lecture	4.6 TLM System and Data Flow Lecture	4.7 CMD System and Data Flow Lecture	4.8 Tracking Data System and Data Flow Lecture	4.9 Operations Interface Lecture	4.10 User Equipment and Telem Format Lecture	4.11 MTC Total Capabilities Lecture	5.1 Navigation Team Training	5.2 Spacecraft Team Training	5.4 Command Team Training	6.1 MO/SFOF: H Nominal Cruise Operations	6.2 MO/SFOF: H Nominal Launch Operations	7.1 MO/TDS: TLM and CMD Training, DSS 12	7.1 MO/TDS: TLM and CMD Training, DSS 14	7.1 MO/TDS: TLM and CMD Training, DSS 41	7.1 MO/TDS: TLM and CMD Training, DSS 51	7.1 MO/TDS: TLM and CMD Training, DSS 62	7.1 MO/TDS: TLM and CMD Training, MSFN ACN	7.2 MO/TDS: H Nom Traj Corr Seq, DSS 12	7.2 MO/TDS: H Nom Traj Corr Seq, DSS 41	7.3 MO/TDS: H Nominal Launch	7.4 MO/TDS: I Nominal Launch/H Nom Cruise	7.5 MO/TDS: H Nominal Trajectory Correction	8.1 ODT: H Trajectory Correction	8.2 ODT: I Launch/H Cruise	8.3 ODT: I Trajectory Correction/H Cruise	8.4 ODT: I Launch-Traj Corr-Cruise/H Cruise	8.5 ORT: Launch-Trajectory Correction-Cruise
SFOF																																	
MSA				X								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
360/75													X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
360/75*																													X	X	X	X	X
1108-A													X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1108-B													X	X	X		X							X	X	X	X	X	X	X	X	X	X
MTC	X											X																					
MTVS (orbital training only)																																	
Simulation Center				X								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
GCF																																	
TVSA												X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Voice/HSD/TTY Comm: SFOF Internal											CANCELLED	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Voice/HSD/TTY Comm: SFOF External																		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
DSIF																																	
DSS 12																		X						X			X	X	X	X	X	X	X
DSS 14																			X												X	X	X
DSS 41																				X					X		X	X	X	X	X	X	X
DSS 51																					X					X	X	X		X	X	X	X
DSS 62																						X									X	X	X
DSS 71																										X	X			X		X	X
MSFN																																	
ACN																							X										
Total committed NEP support																											X			X			X
AFETR																																	
Total committed range support																											X			X			X

*Alerted only for typical mission backup support:

1) Support in case of prime computer failure.
2) Support during critical mission periods.

Table 34. Summary of near-Earth TDS support of MM '71 MOS training and tests

MOS No.	Date (1971)	Test	Results
7.4	11 March	MO/TDS: Spacecraft I Nominal Launch/ Spacecraft H Cruise	Simulation problems with near-Earth tracking data; otherwise satisfactory for first combined test
8.2	31 March	ODT: Launch Mariner I/Cruise H	Simulation problems, telemetry and tracking; procedure problems with backfeeding data to Building AO; work around of these problems demonstrated readiness to support launch
8.4	13 April	ODT: Mariner I launch trajectory Correction - Cruise; Cruise H	No problems; good test
8.5	29 April	ORT: Launch - Trajectory Correction - Cruise H	No problems; good test
8.5	18 May	ORT: Launch Mariner I	No problems; good test

Table 35. Summary of DSS 71 activity for MM '71 (Sept. 1969 through June 1971)

Activity Code	Station Hours
Compatibility Test Development Compatibility test development included development and testing of both equipment and software for new or updated semiautomated compatibility tests used at both CTA 21 and DSS 71 in support of actual spacecraft/DSIF testing. Activity also included development and testing of new test techniques that may be used.	1283
Near-Earth Trajectory Support Near-Earth trajectory support was provided to the TDS near-Earth group at Cape Kennedy. The group supplied a power flight trajectory magnetic tape and DSS 71 supplied software programming and computer operation to provide view periods for 9 stations for 96 possible launch opportunities. The DIS computer and all associated equipment was used.	284
Near-Earth PSK Demodulator Development Test The TDS near-Earth group at Cape Kennedy were assigned the responsibility to design and provide to the near-Earth supporting stations a PSK demodulator for MM'71. Development of the PSK demodulator employed the DSS 71 receiver, SCA, SDAs, and TCP for test and evaluation.	89
DSN Reconfiguration and Update All system and subsystem cables were removed; all subsystems were relocated; existing equipment underwent major modifications; and SSA, BDA, SCA, CMAs, and HDRs were added as new equipment for MM'71 support.	604
DSN Integration Test Integration tests consisted of telemetry and command tests internal to the station as required by the DSN test/training plan for MM'71.	308

Table 35 (contd)

Activity Code	Station Hours
Near-Earth Telemetry Tests Near-Earth telemetry tests involved testing the interface between DSS 71 and near-Earth supporting stations for real-time telemetry transmission.	45
RF Link Testing DSS 71 has RF links from Bldg AO, explosive safe facility, Pad 36A, and Pad 36B. RF links were required for spacecraft testing at each of these facilities. Activity was performed in the installation and calibration of these RF links.	36
Operator Training Operator training consisted of both classroom instructions and actual operation of equipment.	112
DSN Scheduled Test DSN scheduled tests consisted of OVTs, MOS, ODTs, and system tests scheduled from the DSN for MM'71 support.	115
S/C Prelaunch Support Prelaunch support was provided for the PTM and both flight spacecrafts. Activity consisted of processing telemetry and sending commands during practice countdowns, precountdowns, and J-fact tests.	124
Spacecraft/DSIF Compatibility Tests Activity consisted of formal spacecraft/DSIF compatibility tests on both flight spacecrafts.	67
Launch and Post Launch Support Activity consisted of processing telemetry from the spacecraft and near-Earth stations during countdown and launch of both spacecrafts. Some post-launch testing with SFOF was also involved.	70
Total	3137

Table 36. Lecture presentations

Lecture number	Speaker	Topic
1	R. K. Mallis	Introduction and Section 337 Organization
2	R. T. Hayes	Mission Operations
3	J. H. Duxbury	Spacecraft Systems
4	D. M. Scott	Spacecraft Radio Subsystem
5	W. H. Chitty	Spacecraft Command Subsystem
6	C. E. Geuy	Spacecraft Telemetry Subsystems
7	I. L. Emig	Operator Training Schedule
8	J. R. Buckley	Station Countdown Philosophy
9	R. C. Chernoff	DSN/DSIF Monitor System
10	H. C. Thorman	SFOF Simulation Center
11	E. Garcia	Simulation Conversion Assembly
12	D. L. Gordon	DSN Operations Control Team
13	R. L. Chafin	DSIF Software Program Support
14	D. Nightingale	Introduction to Upgraded High Speed Data System
15	R. W. Burt	System COE Functions
16	R. B. Miller	SFOF Tracking System
17	W. H. Higa	Time Synchronization Systems
18	J. G. Leflang	Block III Masers
19	C. P. Wiggins	DSS Transmitters

Lectures 14 through 19 were attended by supervisors only.

Table 37. Operational tests

Tests	Station							
	ACN	12	14	41	51	62	71	Total
DSIF OVTs	4	13	12	12	11	10	4	66
MOS Launch I/cruise H	3	3		7	7	3	7	30
MOS Trajectory correction		1		5	5	1		12
MOS Trajectory correction 67-h test		—	—	—	—	—		
MOS Trajectory correction 85-h test		—	—	—	—	—		
MOS ORT	—	—	—	—	—	—	—	
DSN combined systems tests		6	1	3	3	3	2	18

Table 38. DSN/MM '71 network systems tests

Station	Date, GMT
12	16 and 18 Dec 70*
41	28 Dec 70
51	30 Dec 70
BDA/CYI (NEP)	22 Feb 71
71, ACN, BDA, MILA, ANT, VAN (TDS/NEP)	23 Feb 71
12	9 Mar 71
51 and 71	10 Mar 71
41	12 Mar 71
62	13 Mar 71
41 and 62	20 Mar 71
41 and 62	25 Mar 71
12, 14, 41, 51, and 62	29 Mar 71
12, 41, 51, and 62	12 April 71
12, 41, 51, and 62	23 April 71

*Test repeated

Release Date (1971)	JPLOS Version		Mission Software (Model)	Mission Software (Version)
16 Feb	2.5.047		1	40
19 Mar	2.6.069		1	40
22 Mar	2.6.069		2	23
25 Mar	2.6.069		2	26
9 Apr	2.6.091		2	26.4
19 Apr	2.6.091		2	26.5
20 Apr	2.6.091		2	26.6
26 Apr	2.6.091	(Launch System)	2	26.7

Table 39. DSN systems test problem summary, Dec. 16, 1971

Telemetry Deficiencies
(1) Problems experienced with Simulation Conversion Assembly (SCA). (SCA amplifier output found to be deficient)
(2) TCP reporting low signal-to-noise ratio (SNR)
(3) Abnormal MISSED DATA BLOCK experienced with Telemetry Processor (TP)
(4) Unable to reliably process complemented data from DSS
(5) Experienced unwanted duplication of latest available data dumps
(6) Problems with data tables and display interpretation
(7) No SFOF User Guide documentation
Command Deficiencies
(1) Of at least 40 verification attempts, none was successful.
(a) In comparing SIMCEN dumps of SFOF to DSS 12 and DSS 12 to SFOF HSD command blocks, at least one instance was identified in which all pertinent bits in the two blocks matched, but SFOF failed to indicate a verify.
(b) During the above comparison, another set of HSD blocks indicated that DSS 12 was incrementing the message number in the HSD block received from SFOF (DSS 12 should have stored this number as received).
(2) MM'71 QC and CC commands (if entered in alphanumeric code from the MSA 2260) would process through the verification and execution cycle correctly, but MM'71 DC commands could not be processed through the verify cycle.

Table 39 (contd)

(3) If the QC and CC commands were entered in pseudo-octal, rather than alphanumeric code, from the same 2260 as in (2) above, they could not be processed through the verification cycle. (4) Even though the direct commands (DC) were not verified, DSS 12 manual recall of the command stack indicated some DC were being input into the TCP as expected. (5) The coded/uncoded flag bits were improperly set in the HSD command block, but apparently only in instances in which the verify cycle was unsuccessful. (6) DSS-originated alarms were confused and occurred at unexpected times (e.g., DSS 12 reported its exciter was on, but the alarm that the exciter was off was repeatedly received at SFOF). (7) Apparently the manual enable functioned properly when exercised.
Tracking Deficiencies
(1) The SFOF Tracking Software for this test consisted of the TCP in a Model 1 configuration. Predictions and pseudoresiduals were not used in this test as they were not accepted by the Cognizant Engineers. Tracking data were transmitted from DSS 12 and 14 by TTY to the 360/75 via the CP. All elements of the Model 1 TDP were exercised; however, significant results were obscured because of the failure of the 360/75 (down at least eight times during this test). Each failure of the 360/75 may cause loss of the DSN Tracking SDR and data must be recalled from various sources (Station, CP or 360/75 log tape). After many tries, a Project tape was generated for DSS 14 Pioneer (PN) 6 data and successfully read by the Project ODE. A Project tape from DSS 12/PN-7 data was not completed before the end of the test, although it was attempted. The reason for failure to write a Project tape for DSS 12/PN-7 was not determined.

Table 39 (contd)

(2) Another problem, not associated with this test, was discovered in the Model 1 TDP in that receiver reference frequencies were picked up from the point-by-point TDH data and placed point-by-point on the Project tape for data reduction. There was no manual means for adding this frequency to the Project tape in Model 1 TDP. Two problems resulted: (a) Some TDH formats did not include the receiver reference frequency, and   (b) The counter that put this frequency in TDH format was quite unreliable.
Operations Control and Monitor Deficiencies
(1) Digital Television (DTV) display times would remain the same for several updates, then take a large jump.   (2) HSD block serial numbers (BSN) sometimes displayed in decimal, sometimes in hexadecimal, would sometimes increment erratically.   (3) The 360 would halt when the same format was called up for more than one DSS.   (4) When changing RCVR 2 parameters to confirm monitor data, indications of RCVR 1 parameter changes were also received.   (5) Could not use cursor to update single parameter of a Manual Entry Device (MED) entry; had to retype entire entry. Indications (MCD) of illegal parameters in entries; specifically, parameter Display was illegal. Subsequent page prints on 1443 listed parameter as display.   (6) Monitor DTV format 3 is a multiple-DSS summary; it must be called up by entering any DSS number, then all other DSS that are up automatically appear (it is cancelled by using the same DSS number).   (7) Parts of DTV formats would occasionally be missing. The problem was sporadic.

(8) MCD sets automatically made a print on 1443 when activated. This should be an option as the 1443 will often not be available for long periods when in use for SOE production; MCD set activation cannot wait for a 1443 to become available.

(9) It was reported that the output router was terminating transmission before the message was complete. Although true for TTY output, it is not true for HSD output. The first 15 items (and header) were not received on the second of three SOE transmissions; otherwise, all messages sent by HSD were received intact. There were occasional print errors, far more than can be accounted for by GCF errors.

(10) Only DSN Schedule was sent by both TTY and HSD. All HSD transmissions were perfect, but about half the TTY transmissions terminated after the first line of the title.

(11) The Digital Instrumentation System (DIS) printed a ">" instead of a "=" (may be a coding error). DIS also consistently shows a DDT of 163 when it should be 165; possibly an error in a canned parameter.

(12) Whenever the output router abends, it stays down until a 360 restart. This is very undesirable as the router is needed the most during critical activities when there is the least possibility of interrupting other system data for a restart.

(13) SFOF and DSIF use different page size in their printers, resulting in top of forms coming in the center of DSIF pages. Besides looking peculiar, it prints through large collating holes at bottom of each page.

(14) Master Control and User Interface (MC&UI) cannot yet handle multiple routing indicators.

(15) Output router testing was hampered by inability to obtain page print of data going by HSDL. Worse, DSN Operations Design requested availability of such data for validation and operation.

Table 39 (contd)

(16)	Inability to selectively dump incoming data hampered both Command and Telemetry. Finally, SIMCEN performed this function. Existing dump capability is nonselective, i.e., everything on the line gets dumped. Since this creates a queue, it automatically times out after 20 seconds.
(17)	Could not locate the PREDIX files.

Table 40. DSN systems test problem summary, Dec. 28, 1971

Telemetry Deficiencies	
(1)	When initiating a bit rate change, wrong data dependent codes were inserted in the HSD header by the TCP.
(2)	Because wrong DDT were received from the TCP, wrong time tags were observed in the line printer data.
(3)	Experienced lost formats on line printer.
(4)	On an entered-PN-error format, a wrong time tag was displayed.
(5)	Three formats, i.e., no data, bit rate change, and phase time, had time tags of zero.
Command Deficiencies	
(1)	A HSD block containing MM'71 DC, CC, and QC priority commands was verified and confirmed.
(2)	The same HSD block as in (1) above, but timed and manual enable rather than priority, was verified, but, on the block manual enable, only the first command in the block was enabled.

Table 40 (contd)

(3) After (2) above, the same HSD block went through verify and manual enable properly (this time the DC, CC, and QC in the block were enabled by three separate enable messages rather than by one block enable message). Only the first command (a DC) was confirmed, the second command (a DC) was aborted, and the remaining six commands (a mix of DC, CC, and QC) were not executed by DSS 41 when their time came. (4) When the DC command, aborted in (3) above, was sent to DSS 41 by itself, it was aborted again, but this time a different abort reason was printed out in the MSA than was printed out in (3); the abort reason printed out at DSS 41, however, was the same as it was in (3). (5) A COMGEN run of mixed DC, CC, and QC priority commands was attempted, but only the first block was sent by SFOF (this is a known anomaly to be corrected in a later SFOF model). Commands in this block were verified, but only the first seven were confirmed; the last command (a CC) was aborted (on the same bit as the aborts in (3) and (4)).
Tracking Deficiencies
1) The test on 28 December 1970 was terminated early because of a failure in the CP to 360/75 interface. No results were obtained from this test.
Operations Control and Monitor Deficiencies
(1) As in previous systems tests, lack of documentation, such as User Guides, hampered operations. (2) The lack of a CP/CPS interface (CP to 360), because of equipment problems in the 360, affected both Monitor and Operations Control testing.

Table 40 (contd)

(3) The 1443 printers experienced a type bar miscarriage abnormality. The type bar on the printers slips to one side where the control mechanism fails, resulting in the printer becoming inoperable. This seems to be a facility-wide problem in SFOF CPS.

(4) DTV display times, as in previous system tests, were sporadic. The times would remain the same for several blocks and then take a large jump.

(5) BSN on simulated DTV formats were printed in hexadecimal. There was some question whether the block number on the formats was intended to be a BSN.

(6) The MCD set processor flagged numerous errors in the post assembly listing on the 1443. These errors were of undetermined origin as the input tape, which was read by the 360 when the M15 MED was entered, was the same tape used for previous tests and had been certified (by dumping) as a good tape.

(7) The Monitor area 1443 printer (unit address 473) became inoperative because twice the type bar slipped. Each time the 360 real-time job step had to be restarted. Unit address 473 was the only printer that had this problem, caused by the 2909 interface to the 1443 printer.

(8) Again, as in previous tests, the output router terminated transmission of a TTY message before the entire message was complete.

(9) As already stated, HSDL routing could not be tested.

(10) Multiple routing through MC & UI was also a problem and appeared to be the cause of some operational anomalies. These anomalies caused delays of a procedural nature and demonstrated need for procedures, operator training, and systems documentation.

(11) Predicts transmissions via TTY to DSS 41 could not be accomplished because of lack of a test case in the 360 and the fact that the Tracking System could not generate predict files during the test.

Table 41. DSN systems test problem summary, Dec. 29, 1971

Telemetry Deficiencies
(1) Procedural problems (between SIMCEN and DSS 51 SCA) delayed test start by two hours.
(2) Intermittent HSD service experienced for approximately one hour at start of test. Problems were reported with NASCOM. No retrain cycles reported.
(3) Many 360/75 restarts created serious problems throughout test with maintaining 2260 test control.
(4) Observed both successful and duplicated Latest Available Data (LAD) dumps.
(5) Two priority A formats, 731 and 599, showed time regressions of from 1 to 3 minutes.
(6) D-MEDS could not be entered from card reader in DPCC.
Tracking Deficiencies
(1) Predictions and pseudoresiduals were not available (Model 1).
(2) This test was again marred by failures in the 360/75 system resulting in restarts. Each failure causes the loss of the SDR unless it was written from disk to tape.

Table 42. DSN combined systems test problem summary, Mar. 8, 1971

Telemetry Deficiencies
(1) Entered selected DTV formats via selector box. Because of an oversight, old formats had to be deleted via 2260 keyboard before a new format could be selected or the formats would overlay. One could not reselect the same format for a channel while it was active because the 360/75 would fail.

Table 42 (contd)

(2) In activating the system, real-time operators called up an abundance of 1443 and TTY formats for the assigned devices. This caused the devices to back-log data and run as high as 8 to 12 minutes late. (3) The 360/75 failed when range suppression tolerances were used, and a list of all data associated with range suppression was requested for 1443 display. (4) On bit rate change from 33-1/3 to 8-1/3 (spacecraft (S/C) 84), format 733 (bit rate change) on the 1443 printer was not noted, nor did format 733 print out when changing back to 33-1/3. S/C 85 was not checked on 8 March. (5) The Pseudo Noise (PN) Sync code of 03544 vice 03545 (the correct PN Sync code) functioned normally. However, when a PN tolerance of 1 was entered, the system did not frame sync. Normal frame sync can be reachieved by re-entry of a PN tolerance of zero and the correct sync code of 03545. (6) Item 33 called for PN bit error (BE) of 77. This step was a prelude to test SOE Items 34, 35, 36, and 37, which input a false sync arrangement into engineering channels 117, 118, and 119 event counters. When the PNBE of 77 was entered, the TP began abending; the 360/75 failed when bit error was not zeroed as soon as possible. (7) Items 38 through 44 appeared to function normally; on Item 45, engineering units coefficients changes/modification, the input processor did not accept 2260 MED entries. (8) Data recall was successful except that data cannot be recalled from a time frame before a computer fault. This was expected, but should be rectified to allow complete time frame recall capabilities.
Command Deficiencies
(1) Test Command did not verify the first time when DSS initialized TCP B for commanding vice TCP A. After initializing TCP A for Command, the test command verified.

(2) No attempts were made to transmit standards and limits, on configuration tables because of known problems encountered performing this step in previous tests. (3) No attempts to run COMGEN were made because of problems encountered when performing this step in previous tests. (4) The automatic enable function failed to operate. Problem was procedural. Network Analysis Team (NAT) 2260 was assigned to both Command Analysis Group (CAG) (for Command readiness) and Project (for Command Operations functions within SOE). The CAG assignments inhibit the automatic enable function. (5) When attempts were made to send card file commands, the 360/75 failed. Both the command message and enable message were received by DSS 12, but as the commands were clocking out, the 360/75 failed.
Tracking Deficiencies
(1) Because the data package required for Simulation to generate radio metric data was not completed, and because of a question concerning options available for Tracking in the 360/75, participation was limited to predict and Phi-factor set generation for simulation and library. Prepunched paper tapes of radio metric data were made available to SIMCEN, but were not used. (2) Predict and Phi-factor set generation were successful and two files were transmitted to DSS 12. (3) Files of predicts were written over the previously generated files, preventing any retransmission to the stations or other use of the files from the computer. (4) Once predict generation was initiated, the option was not available to abort or stop the run and restart; the run in progress apparently must run its normal course. This could cause some problems during critical phases if an error were made in the initiation of a run.

Table 43. DSN combined systems test problem summary, Mar. 10, 1971*

Telemetry Deficiencies
(1) Problems involving the PN mode change and engineering coefficient modifications were rectified by using corrected MED inputs. (2) TTY appeared to be outputting reliable data to all routing indicators (RI), and the 2260 delete TTY MED worked without blowing the 360/75. (3) Engineering range suppression channels did not accept small suppression limit changes, but the data did not react to these limit changes unless a large number were entered, i.e., 999. Two channels in particular were 605 and 707. (4) Line printer and DTV formats performed as required. One line printer format (733), which is a bit rate change functions on simulated short looped data, did not display bit rate change. A dump should be taken of the inbound TCP telemetry data blocks to check the DDT code. (5) PNBE tolerances were changed and the system performed as required with no anomalies. (6) Tests were made to verify engineering units coefficients, which were found to function as required. (7) Problems still occurred with DTV selector boxes.
Command Deficiencies
(1) No attempts were made to run COMGEN because of problems encountered while performing this item in previous tests. (2) Standards and limits were successfully transmitted two times using Version 23.2. The configuration tables still cannot be transmitted. (3) The command system can be accessed by card files. Command and enable messages were received by DSS 51, and DSS 53 commands were successfully transmitted.

Table 43 (contd)

Tracking Deficiencies
(1) Although DSS 51 was participating in the Combined Systems Test, radio metric data for Tracking System operations were short-looped from SIMCEN to the CP and 360/75 facilities. No radio metric data were sent to or received from the station. The data package consisted of prepunched tapes simulating DSS 51, MSFN 75, and DSS 41 data.
(2) Predict and Phi-Factor set generation were again attempted and were successful. One file of predicts was transmitted by TTY to DSS 51 successfully.
(3) The pseudoresidual program was exercised with DSS 51 data; after a few procedural problems, the program was successful. However, in attempting to exercise the program with DSS 51 and DSS 41 data simultaneously, only DSS 51 pseudoresiduals were output to TTY and DTV. Many options and MEDs were attempted to get the DSS 41 output, without success. Attempts to run the program on DSS 41 data alone were also unsuccessful because of a switch from the B string to the A string at the time. Attempts to get the Phi-Factor tape read from tape to disk on the A string were unsuccessful; it possibly could have been a procedural error in the computer section.
(4) One problem was the use of the MED sequence R47, R43, R48, and R46 to delete a Phi-Factor set. On attempting to delete one set in a group of three sets, it was found that all three sets were deleted. It is recommended that this problem be studied and it be determined whether this is the intent of the MED or if possibly another sequence or a different sequence is applicable.
(5) Another problem or annoyance is the requirement to set the year to 71 for the data to be processed. Since all MM'71 used are year 71, the default to year 70 seems invalid. It is recommended that the default be to year 71 instead of '70'.
(6) Different data display MEDs were exercised and all were successful.

Table 43 (contd)

(7) Another problem was the computer string change procedure. Tracking was not given enough time to dump data to tape before the system switch was made. Although data recovery from one system to the other was to be accomplished by data processing, it was found that no data were available after the exchange. It is recommended to determined whether disk-to-disk data recovery can be accomplished during string swaps and if enough time is allowed to dump data to tape before swaps are made.
Operations Control and Monitor Deficiencies
(1) The primary exercise for OC & M on both tests was using the output router. Numerous errors on most transmissions occurred on 8 March. (2) On 10 March 1971, a tape was made (SOE for Project Test 7.4) and successfully transmitted to DSS 51. When commands and output router were operated simultaneously, some interaction occurred (not, however, when the output router was exercised by itself).
*DSS 71, first 3 hours; DSS 51, last 8 hours. Model 2 Version 23 software, first 7 hours; Model 2, Version 23.2, last 4 hours. Some 8 March Test problems solved.

Table 44. DSN combined systems test problem summary, Mar. 24, 1971*

Telemetry Deficiencies
(1) TTY Telemetry Format 711 did not enter or exit range suppression or alarms. (2) Problems were encountered when trying to create a CC&S compare mask file using COMGEN program. Two separate card decks, one

Table 44 (contd)

which creates a mask for SIMCEN data, and one which creates a mask for spacecraft data, were tried on four separate occasions. Each time the run was terminated because of 360/75 software system failures. No direct correlation exists between the four system failures and unsuccessful attempts to create the CC&S compare masks. A successful command file was created using COMGEN. (3) Format 733 (spacecraft bit rate change for 1443 line printer) did not print out changes to bit rates on occurrence. Bit rate was changed several times by SIMCEN to test this format printout but the change did not occur on either Spacecraft 84 or 85. (4) Test sequence was not fully exercised because of numerous failures of the CPU. Items not tested were Engineering Unit Coefficient Modifications and SDR Recall. (5) 360/75 failures were numerous and seemed to occur when Monitor, Command, Telemetry, and Tracking processors started to back log data (usually about 8 to 10 minutes behind). The system seemed to start back logging data when programs such as COMGEN, PRDIX Generation, or SOEGEN were being run under real-time job step. (6) Telemetry DTV Formats 644, 645, 646, and 648 would not update because static data was in the system. On ramping engineering channels, formats were updated with correct values, creating the feeling that the format does not function correctly if there is no change in data. However, in a later version software, formats will update every 5 seconds.
Command Deficiencies
(1) Commands transmitted to DSS 62 A got into 62 A and 41 A. These commands were transmitted and confirmed by both stations. No answer has been given for this problem, and it could not be duplicated.

Table 44 (contd)

TTY R/Os and the station SMC R/O are available for review. The circumstances leading to the Command anomalies were as follows:

(a) 360/75 Version 26

(b) C04 Configuration

Assign	DSS	CAG
50	41A	041
41	62A	
41	62B	
41	14A	

(c) MSA was in process of sending card file CM 7124 to DSS 41 A. CAG was sending priority, immediate enable commands to 62 A.

(d) Commands sent to DSS 62 A did not verify in eight attempts; they were retransmitted. The commands then verified. The first and second attempts at transmissions were both received by the TCPs. Therefore, the second message arrived after the second confirm of the first transmissions.

(e) The command message 107 (which is the message that got into both TCPs) was transmitted to DSS 62 A at the exact time of the verify of the first of the card file blocks from DSS 41 A.

(f) Confirm of the first command of block 107 at DSS 62 was 02:44:57. Confirm of the first command of block 107 at DSS 41 was 02:44:52.

(g) Neither the SMC R/O at DSS 41, or the TTY assigned to DSS 41 reflected the transmissions of command block 107 to DSS 41 or the receipt of the message by the DSS.

Table 44 (contd)

Tracking Deficiencies
(1) A Project tape was made from Simulated DSS 12 tracking data (S/C 84) recalled from the CP. ODE listing showed 264 points on the input tape but only 189 points on the ODE file. Inspection of the listing indicates that the sample rate was set to zero intermittently and then continuously at the end of the run.
(2) When the 360/75 failed nine times, SDR generation activity became very time consuming since the tracking SDR is lost on disk every time the 360/75 fails.
(3) Tracking data processor software functioned except for the above mentioned SDR recovery. All files had to be reloaded, including data from either recall from the CP or the station, frequencies re-entered, and pass summaries reinitialized. Each SDR recovery activity consumed approximately 20 minutes, depending on amount of data to be recovered.
(4) In general, the 360/75 failed so often that the procedure for writing check tapes to preserve the SDR could not be demonstrated until late in the test.
(5) Capability to merge archive tape with the current SDR into a Project tape was not exercised.
(6) Four days of predictions (two-way only) were generated for DSS 12 for PN-8. Wall clock run time was approximately 35 minutes. When the probe ephemeris tape was removed, it was discovered that the 360/75 computer operator had mounted the probe ephemeris tape for PN-6, thus neatly making PN-6 predictions with PN-8 frequencies and headings. The run demonstrated that tape numbers for predicts generation should be controlled by the 2260 in the Network Analysis Area.

Table 44 (contd)

Operations Control and Monitor Deficiencies
(1) DTV Format 02 (Monitor summary block) could not be initialized from 2260 request box on card reader. Summary block, including the header, was processed as if it were all zeros. D-66 dumps confirm that there were data in blocks.
(2) SOE generator could not be run to completion under the real-time job step.
(3) Format 101 was always overlayed by its verify messages (DTV channels 47 and 48).
(4) If formats 108, 109, and 110 were requested on DTV channels 47 or 48, and they had already been called up on lower channels, the formats appeared twice on the lower channels and did not appear on DTV channels 47 or 48.
(5) The output router could not be used while predicts, COMGEN, or SOE-GEN were being run without blowing the 360/75.
*Mark IIIA Mode 2, Version 23. 2 and 26. 2 differences summarized; known exceptions included.

Table 45. DSN combined systems test problem summary, Mar. 29, 1971*

Telemetry Deficiencies
(1) A major problem occurred processing data from Spacecraft 76 and 86. Apparently the 360/75 data suppression file, created by the TLMMOS standard, MM'71 suppression deck does not recognize these spacecraft I/Ds. Data from these spacecraft can be suppressed by keyboard entry or by card decks identifying the particular spacecraft and channels desired for suppression. Until the problem was recognized, the 360/75 faulted twice because of data logging.
(2) When processing four spacecraft and ramping data in the engineering 100 commutation deck, the 360/75 would quickly start to run behind.

Table 45 (contd)

Unless new suppression tolerances were input to the system to accommodate the new values, the system progressed to the point of no return and failed. (3) Procedure Items: MED entries should be routed to the 2260 without keyboard vice the 1443 in the Telemetry Real-Time processing area because of the amount of data processing required for that area. MED entry printouts may require as much as five minutes to print out, especially if many keyboard entries are required. These MEDs take up valuable time which could be used for outputting processed data. (4) Ways and means must be undertaken to reduce the telemetry data processing load if the 360/75 is to become reliable under optimum conditions.
Command Deficiencies
(1) DSS 51 did not send confirm messages to SFOF. NAT Command suggested a TCP reload that corrected the problem. (2) DTV channel 47 overlayed Format 101 as per examples given on previous test report (Section IX, paragraph E). Formats 107, 108, 109, 110 missing from DTV 47 and 48 and appearing double on Project DTV channels 16 and 19. (3) No confirm messages received from DSS 41. NAT Command recommended a TCP reload that corrected the problem. (4) An attempt at changing the subcarrier frequency with a configuration message was made with DSS 51. The configuration message changed the value in the TCP (result of a configuration recall), but did not change the FO frequency in the CMA. This appeared to be a software problem common to all stations.

Table 45 (contd)

(5) DSS 14 loaded the patches to the TCP program improperly. These patches were sent out to cure the following: (a) Bit rate limit alarm (b) Can in an abort return to Idle 1, and 3 (allow change to the CMA mode with a configuration message). Improper loading of these patches caused the TCP/CMA to abort return to active mode, cured by a TCP reload and a reloading of the patches. (6) Repeat of the same DTV 1 problems reported for two months: Overlay of Format 101, and problems with Formats 107, 108, 109, 110 (7) Confirm messages coming back from DSS 62 show unreliable data, such as: (a) Incorrect pseudo-octals (b) Incorrect message numbers and subnumbers The SMC R/O at the DSS shows correct readings. An exchange from primary to the backup HSD equipment at the DSS corrected the problem.
Tracking Deficiencies
(1) The data package prepared for the test consisted of simulated radio metric data for S/C 84 during the launch phase, to be tracked by DSS 51 and MSFN 75, and for S/C 85 during the cruise phase, to be tracked by DSS 12, 41, and 51; and PN-6 and PN-8 data punched from an active pass, as tracked by DSS 12 and 51. Operational problems precluded processing any but the PN-8 data, again limiting the test to a single S/C test. The 360/75 system had six failures during the period that required re-initialization of Tracking System activities. During initialization

of the 360/75 system itself, the 1443 printer, 473, in the NAA had a print bar failure, disabling the printer. Printer 476 was allocated to the Tracking System operations, to be shared with other functions. Backlogging was experienced almost immediately. After the first failure of the 360/75 system, printer 482 was requested by Tracking Operations, and, after some difficulties in getting the printer properly assigned, this printer was used until the area printer 473 was repaired.

(2) The pseudoresidual program was exercised with PN-8 data only because of operational problems. The program did not compute values for one-way tracking; values for two-way tracking were computed, however. The problem of the program searching the Phi-Factor sets on file and using only the first one encountered with the proper Spacecraft identification, regardless of the time period covered, creates a time-consuming process of reading the files to tape, deleting the sets from disk, and restoring only the set applicable for the time period. If a pass includes the period covered by two sets, both sets cannot be entered at the same time, for the program will not go to the second set. It is recommended that the search be expanded to include set number and time as well as spacecraft identification.

(3) The problem of the 360/75 failing after predict requests were initiated, requiring re-initialization of the request, prevented generation of predicts for PN-6 and PN-8 and was finally completed for S/C 85 during the last hour of the test. On two requests for Phi-Factor output, a SOE was printed; the second time the SOE was part of and at the end of the Phi-Factor output.

During the test, three attempts to generate predicts resulted in abends, with code 004. Reason for this result could not be determined.

(4) The option of writing from disk to tape, then restoring disk from tape, was exercised with the result the Frequency Files originally on disk were lost on the restore.

Table 45 (contd)

Operations Control and Monitor Deficiencies
(1) The previous problem described in the 24 March, Test Report concerning DSS 12 receipt of Operations Control data had been cleared at test start. Errors for text transmission of data were nominal in comparison to other DSN tests and receipt of Predicts data to generate a mag pak was demonstrated.
(2) The Operations Control router software in the 360/75 performed well, but the procedural problem of not being able to send out Predicts data in both floating point and text with one message entry to the 360/75 and display the Predicts 'in-house' could be very cumbersome for operations in the mission phase. Procedures are needed to enable the 360/75 to generate an IPL between transmission, etc.
(3) The SOE generator was run under the real-time 360/75 system during the test, but the generation of a magnetic tape for the Operations Control router could not be demonstrated. After several attempts to run SOEGEN, the test supervisor ceased further efforts to verify the program because of other system requirements for the test.
(4) Monitor data alarm processing could not be tested as software was not available.
(5) Monitor DTV processing was unchanged per last test of OC&M on 24 March.
(6) Monitor DTV requirements are being reviewed for priority of repair and implementation based on test performance and evaluation of data displayed.
*DSS 51 and 62, first 6 hours; DSS 12, 14, and 41, last 6 hours; short-loop MSFN data processed, first 2 hours. During 3-hour overlap, 5 data streams processed simultaneously while commanding 2 DSS.

Table 46. DSN combined systems test problem summary, Apr. 12, 1971

Telemetry Deficiencies
(1) The 360/75 Line Printer Format 599 (full frame data) was minus the high deck engineering channels 104, 105, 106, 107, 108, and 109. This unexplained condition lasted approximately 15 minutes. COMGEN failed to create a CC&S compare mask because of insufficient disk space allocation.
(2) Problems with telemetry DTV formats and the inability to suppress the Ground Receive AGC were noted as consistent with problems documented during the MOS Test and OVT Test of 8 and 9 April.
(3) During the last two hours of the test, the 360/75 used Software Version 26.4 with correction data sets for the DTV and suppression problems. Since this version was only a test bed case and not part of the DSN Combined Systems Test, inadequacies observed were noted and developmental Discrepancy Reports initiated.
(4) The Network Analysis area, in specific the Telemetry Operations personnel, exercised various portions of the SOE which will concern their cruise mode operational efforts.
Command Deficiencies
(1) During the Data Flow Tests, DSS 41 would not accept data over HSDL. Switching from TCP-A to TCP-B had no effect. Switching from prime to backup HSD system solved the problem. At the end of the test (approx. 8 hours later) an attempt was made to duplicate the problem by switching back to the original configuration, but the system worked.
(2) There were two discrepancies in display Format 10 (command status): (a) It showed a slash (/) instead of an asterisk (*) when the TCP was in lock, and (b) It showed the same HSDL for both stations.

Table 46 (contd)

(3) During Alarm Test 4 in the SOE, a command that exceeded the maximum time of execution was sent over the HSD system to DSS 12. No alarm message was received at SFOF or the station; however, the command did not go. This was verified in the confirmation message. The same command was entered manually at the station with the same results. A similar test with DSS 41 was not possible because of lack of time.
Tracking Deficiencies
(1) The data package prepared for the test consisted of simulated radio metric data for S/C 84 during the launch phase, S/C 85 during the cruise phase, and PN-6 and PN-8 data punched from an active pass. Again, operational problems precluded processing data at test start time, and only the S/C 85 and PN-8 (S/C 20) data were used from the original data package. Radio metric data from DSS 14, containing TAU ranging and DRVID (on translator) data, were included in the test. All radio metric data were short-looped from the SIMCEN to the 360/75. (2) The Pseudo-Residual Program was exercised with S/C 20 (DSS 12), S/C 85 (DSS 41), and S/C 85 (DSS 51). Generally the operation was satisfactory; however, two problems were noted: (a) Expected or noise calculation is incorrect, and (b) Three-way doppler bias went from a relatively large negative number to zero, then back to the large number. (3) Exercise of the predict program was likewise generally satisfactory. Predicts were generated and transmitted to DSS 12 and DSS 41. Antenna Pointing Subsystem (APS) interface was not checked during the test as the APS computer was being used with the SCA. The interface was checked after the test, and DSS 12 indicates the punched tape

Table 46 (contd)

was satisfactory; however, verification of tape and repunching, using the DIS, was not possible because of DIS changes. Two problems were encountered: (a) A transmission file was written, even though it had not been requested, and (b) Two runs ended with Abend B-37, although the runs appeared to have processed to completion. (4) The Master File Program was exercised with two archive and two project tapes written. The project tapes were given to the 1108 for processing through the ODE interface. Results of this processing have not been supplied as yet.
Operations Control and Monitor Deficiencies
(1) Operations Control transmission of TTY predicts data was successful in that the APS computer read the TTY paper tape. However, a demonstration of the APS computer using a TTY predict tape during a track of a Pioneer spacecraft should be accomplished. (2) During the test, MOTTP 8.4 SOE was used as a test case for transmission to DSS 12 and 41 in addition to normal Operations Control Test SOE data. Five attempts were necessary to transmit successfully the MOTTP 8.4 SOE (1560 HSD blocks) to DSS 12, and only one attempt to DSS 41 because of GCF block errors. Subsequently, it was determined that the errors were caused by the DIS computer interfering with the HSDL. (3) The SOE generator ran and generated a magnetic tape successfully.

Table 46 (contd)

(4) Monitor for the most part remains unchanged. DTV formats are still in need of repair although some of the repair work cannot be accomplished until interfaces between software subsystems and Monitor exists in SFOF.
(5) This test was run using Version A/DIS II software. The next DSN test will use Version B/DIS II software and a reanalysis of the DSN Monitor data displayed at SFOF will be conducted with those DSS involved.

Table 47. DSN combined systems test problem summary, Apr. 23, 1971

Telemetry Deficiencies
(1) In general, the 360/75 demonstrated capability to process four-station/four-spacecraft combination without serious backlogging of the telemetry data, as long as the data was properly suppressed. At times, when the COMGEN program or PREDIX program was running in the real-time job step, the data would backlog approximately two minutes, then catch up after completion of the real-time job step runs.
(2) Telemetry data recall from the DSS, both analog and digital, was demonstrated. The analog data playback was accompanied by real-time vice the actual time of the recording. This condition could possibly be alleviated by use of the time-code translator in conjunction with analog playback. There was also an absence of playback header indication in the line printer and character printer formats.
(3) Recall of the SFOF SDR was demonstrated without backlogging the system as was experienced on previous tests. CC&S data could not be recovered from the SDR. Problem still exists with SDR recall in the areas of inability to write a magnetic tape, inability to recall all the data from a specific time frame when data should exist, and no file protect for the SDR.

Table 47 (contd)

Command Deficiencies
(1) When CAG attempted to change CMA subcarrier frequency with a configuration message by switching the CMA to the CAL-2 mode, then switching to Idle-2 sequence, five confirmation messages were returned from the TCP. (2) Timed commands were sent in the automatic mode because of past problems enabling commands in this mode. During this test, all commands enabled properly. (3) CAG could not get HSD into DSS 41 TCP. Switching HSD systems solved this; however, approximately 45 minutes were required to make this fix. (4) Three command aborts because of bit error failure were recorded at SFOF. The first, at DSS 12, indicated bit 27 failed. The second, at DSS 62, indicated bit 01 failed, and the third, at DSS 51, indicated bit 28 failed. (5) Project command was unable to get a 2260 (logical unit 50), which had been functioning, assigned for commanding to DSS 12. The C0 2 MED entry resulted in a QUEUE FILLED error message. Two attempts were made to correct the problem by disconnecting and reassigning the unit, with no success. At that time, the 360/75 was taken down to exchange systems, and when it was reinitialized, the unit worked. The problem could have been caused by the original 360/75 backlogging. (6) Monitor DTV Format 10 still has errors. (7) Destructive updating of all command formats still exists. In many cases no blank line appears between old and new data.

Table 47 (contd)

Tracking Deficiencies
(1) The data package prepared for this test again consisted of simulated radio metric data for S/C 84 during the launch phase, S/C 85 during the cruise phase, and PN-6 and PN-8 data punch from an active cruise pass. All radio metric data were short-looped from the SIMCEN to the 360/75 processor. The actual time the data were first entered into the system was delayed for approximately two hours, from the planned start time, because of operational problems. However, all data streams were used subsequently. Generally, the test was comparable to previous tests. The 360/75 processor software Version 26.6 was used during the test, and only two system failures occurred. (2) The Pseudo-Residuals Program was exercised with DSS 51 and DSS 12 during the test. Problems still exist in the program in that: (a) Data are inconsistent in Dop Rsid, Noise and Expected Noise, and Range Rsid outputs, and (b) Selection of a station/spacecraft combination data stream is not possible. In the later problem, DSS 51 had two data streams present, S/C 20 and S/C 84, with the pseudoresidual results interlaced on the output devices. (3) Exercise of the predicts program was generally satisfactory, although some problems still exist. An operator was unable to determine from the Listing of Predix File Identification Records the stations included on a Phi-Factor set. This limitation resulted in requiring over 1-1/2 hours to generate predicts, since the computer run would Abend on OC5 until the proper station combination was identified. Predicts were generated and transmitted to DSS 12, 41, 51, 62, and 14 for test of the APS interface. Since the interface could not be checked during the test period, results were reported, as completed. It was noted

Table 47 (contd)

that the file of predicts intended for DSS 14 was not transmitted, but in its place another file was transmitted. This occurred after system swap, so it can only be assumed that the disk packs were not changed with the swap, and that old data available were used for transmission.

(4) The Master File Program was used in the preparation of SDR, and Project tapes IGNORE and SUSPECT options were exercised and properly appeared on the Project tape. MSFN radio metric data were processed with the appropriate DSS 51 data and were output on the Project tape for S/C 84. Numerous edit MED options were exercised; those not available or not working properly were noted. Recall of previous MM69 data was satisfactorily accomplished, and SDR tapes produced.

(5) Recheck of TDH formats 05, 06, 07, and 15 was accomplished from DSS 12 and DSS 41; results were satisfactory.

Table 48. DSN-supported MM '71/MOS training and tests (for both the deep space phase and the near-Earth phase)

MOS No.	Title	Station	Date (1971)
5.0	Mission Operations Team Training*	SIM/SFOF/GCF	27, 29, 30 Jan 11 Feb
6.1	MO/SFOF: H Nominal Cruise Ops	SIM/SFOF/GCF	4 Feb
7.1	MOS/TDS: TLM/CMD Training**	41, 51	2 and 12 Feb
5.0	Mission Operations Team Training*	SIM/SFOF/GCF	15 through 19 Feb
7.1	MOS/TDS: TLM/CMD Training	ACN	18 Feb
7.1	MOS/TDS: TLM/CMD Training	12	22 Feb
6.2	MO/SFOF: H Nominal Launch Ops	SIM/GCF/SFOF	6 Mar
7.4	MO/TDS: I Nominal Launch/H Cruise	71, ACN, ETR, 51	11 Mar
7.2	MO/TDS: H Nominal Trajectory Corr. Seq	41	13 Mar
7.5	MO/TDS: H Nominal Trajectory Corr	12, 41, 51	16, 17, 18 Mar
7.1	MOS/TDS: TLM/CMD Training	62	23 Mar
8.1	ODT: H Trajectory Corr.	41, 51	25 Mar
7.2	MO/TDS: H Nominal Trajectory Corr. Seq	51	30 Mar
8.2	ODT: I Launch/H Cruise	41, 51, and 62	31 Mar
7.1	MOS/TDS: TLM/CMD Training	14	1 Apr
TCD	TCD	36	7 Apr

* 5 each
**2 each

Table 48 (contd)

MOS No.	Title	Station	Date (1971)
8.3	ODT: I Trajectory Corr./ H Cruise	12, 14, 41, 51	8 Apr
8.4	ODT: I Launch-Trajectory Corr. - Cruise/H Cruise	12, 41, 51, 62, 71	13 and 14 Apr
8.4	ODT: I Launch-Trajectory Corr. - Cruise/H Cruise	12, 41, 51, 62, 71	15 and 16 Apr
8.2	ODT: I Launch/H Cruise	51, 71, ETR, ACN, MSFN, 41, 62	20 Apr
8.5	ORT: Launch-Trajectory Correction - Cruise, S/C H	51, 71, ETR, ACN, MSFN, 41, 62	29 and 30 Apr
JFACT	Joint Flight Acceptance Compatibility Test, S/C H	71, Bldg AO	4 May
CRT	Composite Readiness Test, S/C H	71, Bldg AO	5 May
8.5	ORT: Launch-Trajectory Correction - Cruise, S/C I	51, 71, ETR, ACN, MSFN, 41, and 62	18 May
JFACT	Joint Flight Acceptance Compatibility Test, S/C I	71, Bldg AO	23 May
CRT	Composite Readiness Test, S/C I	71, Bldg AO	24 May
8.x	Operational Demonstration Test, MOTTP 8.x	51, 71, ETR, ACN, MSFN, 41, and 62	28 Apr

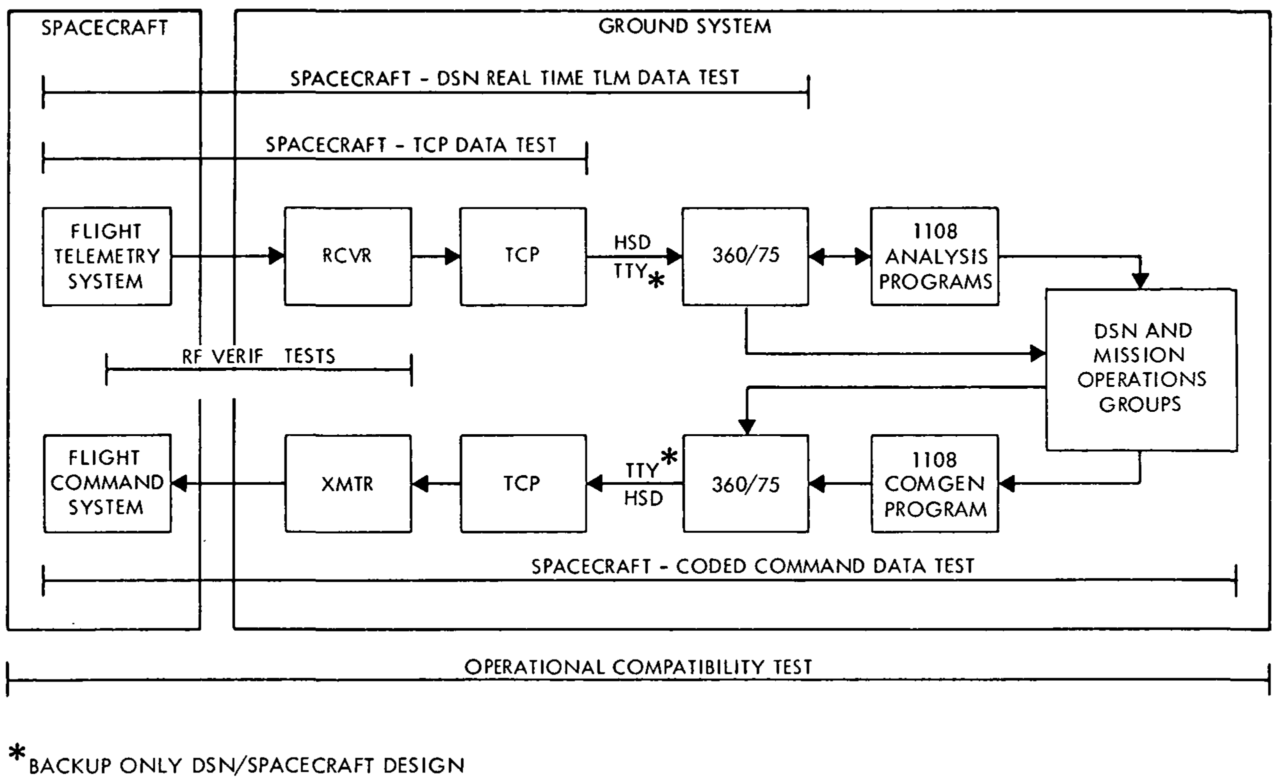


Fig. 58. DSN/spacecraft design compatibility tests

A. Mariner 8 Near-Earth TDS Flight Support

1. Near-Earth TDS countdown. Planned countdown for May 8, 1971, included two built-in holds, one of 60 min at T - 90, and a second of 10 min at T - 10. Liftoff was scheduled for 0111 GMT, May 9, 1971, with a flight azimuth of 101.95 deg, a yaw index of 4.04. Launch window duration was 42 min. Actual countdown time summary is shown in Table 49. Table 50 sets forth launch vehicle event times.

The AFETR support remained in a GO condition throughout the count. ARIA staged from Ramey AFB at 2250 GMT with a predicted ON station time of 0101 GMT. Data flow tests between AFETR, MSFN, and the DSN were performed without incidents. The MSFN remained in a GO condition throughout the count with the exception of one on-site computer at Bermuda that was declared red, the other on-site computer was green with no impact on mission support. Data flow tests between MSFN, DSN, and KSC were performed without incident. No significant vehicle or spacecraft problems appeared. Weather conditions throughout the count were good. High-altitude wind-shear data were within limits. Terminal count operations progressed normally to liftoff, which occurred at 0111:02.294 GMT, May 9, with a flight azimuth of 101.95 deg and a yaw index of 4.04.

2. Flight events. The flight at first appeared to be good, but shortly after Centaur ignition a problem developed in the Centaur control system with a resultant loss of vehicle control and a subsequent loss of the vehicle. Vehicle impact point was northeast of Puerto Rico (23.7°N, 64.5°W) at approximately 0121 GMT. Although not identified from launch vehicle data, the spacecraft separated at approximately 0116:53 GMT. This was determined by the loss of modulation on Centaur channel 13 (spacecraft data channel). Table 51 indicates the stations and times that this event was observed. Near-Earth TDS station coverage is shown in Table 52.

3. HSD transmission. Figure 59 indicates HSD flow from DSS 71 and backfeed to Building AO. During the period between loss of data from Centaur Channel 13 (spacecraft separation) and the usability of spacecraft data from Antigua, there were no data backfed to Building AO. During that period, SFOF began to process HSD from Bermuda.

4. Data return. To evaluate spacecraft flight data, tapes were returned expeditiously from the MSFN and downrange AFETR stations. Signal strength recordings were of particular importance in determining spacecraft tumble rate. In addition, DSS 71 played back to SFOF and Building AO/MTC recordings of data recovered at DSS 71 for evaluation by spacecraft team analysts.

B. Mariner 9 Launch Through Initial Acquisition

1. Near-Earth TDS countdown. Countdown for the launch of Mariner 9 originally was to be conducted on May 18, 1971, but, to allow for the fix on the Centaur vehicle countdown, was delayed until May 29, 1971.

The countdown was to have built-in holds identical to those for Mariner 8. Liftoff was scheduled for 2221 GMT. Countdown was terminated at 2205 GMT during an unscheduled hold at T - 72 min because of an anomaly in the Centaur autopilot ground support equipment. Table 53 is the actual countdown time summary for May 29, 1971.

The second countdown for the launch of Mariner 9 was initiated on May 30, 1971. Liftoff was scheduled for 2217 GMT with a flight azimuth of 92.74 deg; a yaw index of 0.37. Arrival date was planned for Nov. 14, 1971. Actual countdown time summary is shown in Table 54.

The AFETR, KSC, and GSFC network support remained in a GO condition throughout the count. The ARIA staged from Ramey AFB at 2235 GMT with a predicted on-station time of 2210 GMT.

Launch vehicle countdown was held for 5 1/2 min because of a problem with the Atlas propellant utilization system. The problem was verified as being associated with the landline instrumentation system. No significant spacecraft problems appeared. Weather conditions throughout the launch were good. High-altitude wind-shear data were within limits. Liftoff occurred at 2223:04.463 GMT, May 30, 1971, with a flight azimuth of 92.74 deg and a yaw index of -0.34. There was 54 min, 25 s left in the available window. Launch phase spacecraft tracking support provided by the Air Force Eastern Test Range/Manned Space Flight Network (AFETR/MSFN) stations was as shown in Table 55.

Where tracking periods overlapped, selection of the received spacecraft data stream to be processed was based on availability and quality of data output from the tracking stations. Overall tracking support provided by AFETR/MSFN tracking stations during the launch phase was considered nominal. Table 56 sets forth the launch vehicle flight events. Figure 60 shows the Earth track of Mariner 9.

2. Metric tracking support. Estimated and actual radar coverage is shown in Fig. 61. Tananarive had no track because of excessive slant range. This was not unexpected. Data required during that portion of the flight were provided by Ascension. As indicated, Ascension AOS was a little late because the early burn had the Centaur flying a trajectory that did not follow the theoretical. Acquisition aids at Ascension were based on theoretical trajectory. Vanguard had an earlier LOS than predicted. Some dropouts in Bermuda FPS-16 data occurred because of obscuration by the FPQ-6.

3. RTCS computation. Nominal predicts were sent to DSS 51 and ACN at T - 45 min. Table 57 lists RTCS computations for four orbits by data source. A transfer orbit, computed using Vanguard free-flight data after MECO, was considered a poor solution. An IRV, SOPM, orbital elements, and Mars mapping in the B-plane were

provided from this solution. Also, predicts in the DSN format were provided to DSS 51, DSS 62, and the MSFN ACN site. A transfer orbit based on a recursive solution of Ascension data was computed and transmitted. This solution was considered only fair because of noisy data, even though it indicated an almost nominal mission. A SOPM, orbital elements, Mars mapping, and I-matrix were provided from this solution. Also, updated predicts were sent to DSS 51 and ACN.

Next, a B-plane map based on a state vector received from CIF on Centaur guidance telemetry data was computed. The RTCS computed a post-deflection Centaur orbit based on Ascension data. The data span used were again noisy. This solution was considered only a fair fit of the data. A SOPM, orbital elements, I-matrix, and Mars mapping were provided. Orbital elements and Mars mapping indicated that the postdeflection maneuver was nominal.

An actual spacecraft orbit was then computed by the RTCS, using a 90-min span of DSS 51 data. This solution was a fair fit of the data and indicated an almost nominal orbit. A SOPM, orbital elements, I-matrix, and Mars mapping were provided from this solution. A third set of predicts based on this solution was also sent to DSS 51, DSS 62, and the MSFN ACN site.

Mars mapping of the RTC transfer orbits and spacecraft orbit is provided in Fig. 62. Mars mapping by other computer sources (SFOF and GD/C), as reported during NEP, is also included.

4. Telemetry support. Mariner and Centaur telemetry coverage are discussed below.

a. Centaur. Figure 63 shows actual and estimated Centaur telemetry coverage. Bermuda, Vanguard, Canary Island, and Tananarive reported dropouts because of link RF fade. Although the ARIA lost auto track capability, they provided data, as indicated in Fig. 63, using manual track.

b. Mariner. Figure 64 presents the actual and estimated Mariner telemetry coverage. The ARIA data received in real time at DSS 71 never achieved frame sync. Vanguard had a 48-s data dropout.

5. Real-time spacecraft telemetry transmission. DSS 71 processed real-time spacecraft telemetry for transmission to the SFOF as follows:

Time	Source
L - 11 min* to L + 410 s	Building AE (and sub cable
L + 410 s to L + 731 s	Antigua spacecraft data
L + 731 s to L + 1020 s	ARIA spacecraft data (no frame sync)
L + 1020 s to L + 3850 s	Ascension (AFETR) spacecraft data

*Before this time, source was DSS 71 antenna.

Data was backfed to the Building AO MTC as follows:

Time	Source
Minus count to L + 706 s	DSS 71
L + 706 s to L + 1120 s	Vanguard
L + 1120 s to L + 1154 s	Canary Island*
L + 1154 s to L + 1882 s	Ascension (MSFN)
L + 1882 s to 570-min set	DSS 51

*Switched to CYI because of dropout in VAN data.

6. GSFC network post-test (TTY) report for MM '71. The MM '71 Project Support Instrumentation Requirement Document requires a post-test written (TTY) report providing station AOS and LOS times, mark event times in GMT, dropouts, estimates of data validity, explanations of any unsatisfactory performance, and such other data that may assist as guide tools for mission analysis. Accordingly, this report sent from GSFC to JPL is presented in the Appendix.

C. Mariner 9 Deep-Space Flight Support

The Mariner 9 support from initial DSIF acquisition through the first trajectory correction maneuver is described in the following paragraphs.

1. Mariner 9 pass chronology. Seven Mariner 9 passes were supported during the period May 30 to June 6, 1971, which included launch through the first trajectory correction maneuver. DSN coverage was provided by DSS 12, 14, 41, 51, 62, and 71. A total of 95 commands were transmitted to the spacecraft during this period.

Deviations and anomalies listed in the pass chronology are limited to items that significantly affect Project Operations during scheduled inflight DSN support.

Mariner 9 pass chronology for the period from Pass 1 through Pass 7 is given in Table 58.

2. Time lines. Mission time lines, reflecting a tracking profile from Launch, L = 0, through first trajectory correction maneuver, L + 6 days, are presented in Figs. 65-68. Tracking profiles for DSN stations and activities of MM '71/MOS Project, Spacecraft Control Team, Navigation Team, 360/75 computer, and 1108 computer are shown.

3. Telemetry System support. The DSN Telemetry Analysis Group (TAG) evaluated Mariner 9 telemetry system performance from liftoff. The TAG supported all prelaunch testing involving combined systems testing and interface checkout of SFOF, DSIF, and GCF.

Before launch, a station coverage schedule (Fig. 69) was developed and distributed to the operations team to attain complete telemetry coverage. This schedule showed optimum times for the SFOF 360/75 computer to switch between stations during launch phase.**

**Although the launch date was slipped to May 30, the times on the schedule were still valid.

The launch time line proved to be quite accurate; consequently, there were no gaps in the data because of station coverage or computer switching time choices. The schedule also showed allowable PN errors and HSDL channel assignments.

Telecommunications predictions were sent to all participating stations before launch. New predicts to compensate for exact launch time were generated at L + 1.5 h and distributed to the stations. Actual signal levels followed predictions very closely (Table 59). The SNR values were too high to be computed accurately by the station computer program from launch through first trajectory correction maneuver.

4. Tracking System. Tracking System support for Mariner 9 is discussed below.

a. Predict system anomaly. Testing and training before and including the operational readiness test concentrated on providing timely tracking data to the Project Navigation Team. Although basic Tracking System software problems were not corrected in the launch version of the software, a fair degree of confidence that the mission could be adequately supported had been gained by the time of the ORT. Work-around procedures had been learned, the 360/75 was operating for much longer periods between failures, and a backup data source had been established using the 7094 and PDP7.

On May 5, 1971, preflight nominal predicts were generated for the May 8 launch, and the A through X message was sent to RTCS.

On May 6, two days before launch, the Tracking Group (TRAG) was notified that an error had been discovered in the 360/75 predict system. The error involved the pickup by predicts of a value for DUT from the Probe Ephemeris Tape (PET) that was incorrect. (DUT is a constant that relates Ephemeris (ET) to Universal Time (UT). Because it is a slow-changing function of time, the 7094 predict system used it as an input constant that would be updated once a month. The orbit software has it as a polynomial. No method of updating DUT was provided in the original version of the 360/75 predict system. A change was made to obtain DUT automatically from PET.) The error discovered on May 6 was that the value picked up by predicts from the PET was DUT in 1950 instead of the current value, an error corresponding to about 11 s. A work-around existed that involved special trajectory processing for PET purposes.

On May 7, the Predict Cognizant User Engineer, the Cognizant 7094 Engineer, and the TRAG Supervisor met to assess the impact on the already generated preflight nominals. To aid in the evaluation, a 7094 predict run was made on the window-open case. Unfortunately, the 7094 run and the 360/75 preflight disagreed by an amount too large to be attributed to the 11-s DUT error.

To ensure that the effect of DUT was not being misunderstood, a 360/75 was preempted to run the window-open case with a PET run to place the current DUT where predicts expected it. This run disagreed by a larger amount from the 7094 run, in fact, by an amount equal to the original DUT error of 11 s. A perturbing fact was that the acceptance tests cases included a 7094 - 360/75 launch case which had excellent agreement. To double-check this fact, the acceptance cases were retrieved and rechecked.

Something had changed, and no basis existed for determining whether it was in the 360/75 or 7094 run. It was decided to have RTCS provide predicts for the same case which, it was hoped, would prove the 360/75 or 7094 correct. It was decided to have RTCS provide this case as early as possible in the prelaunch period.

The acceptance test case was rerun on the 360/75 with the launch version of predicts, and it agreed with the 7094 acceptance case. Since this run was made on an old PET, it meant that the error was not in the 360/75 launch predict system but was in either the 7094 run or a change in the PET interface.

b. Mariner 8 launch. Starting at about L - 7 h, the middle and close-window preflights were rerun from PETs with a modified DUT. It was elected to transmit these preflights to DSS 51 and ACN even though the 360/75-7094 conflict had not been resolved, because there might not be time later. At about L - 4 h, the special RTCS predicts were run and provided to the stations via TTY at about L - 3 h. They agreed perfectly with the 360/75. The stations were then instructed that they had a good set of preflight nominals.

At L - 1.5 h, NAT TRACK, in reviewing the RF curves, discovered that the DSIF acquisition plan, which included a ±50-Hz search about XA, did not encompass the frequency uncertainty in best lock. A priori uncertainty in best lock was ±62 Hz, thermal uncertainty adds about another ±10 Hz, and ±20 Hz is a good number for trajectory dispersion (if the spacecraft leaves the Earth at all). After discussing the situation with the DSIF, OPS Advisor, and Project Telcomm, NAT TRACK recommended a ±100 Hz search about XA through the OPS Chief.

The rest of the preliftoff activities went more smoothly than in any of the testing. Events which followed liftoff are recorded.

The error in the 7094 run was later discovered to have been in the injection conditions. The 1108 output prints the injection epoch in ET, whereas the 7094 trajectory output is UT, and the 7094 predict system expects to receive the injection epoch in UT.

Proper software correction for the DUT problem in the 360/75 predicts had not yet been established. It was hoped that the correct way to handle DUT could be designed in time to be included in the Model 3 software.

c. Mariner 9 launch. Mariner 9 was the first successfully launched spacecraft to use the combined 1108 PET 360 predicts system. During prelaunch checkout, problems were encountered with the 360 predict system, and, more important, the run time of the combined 1108 PET 360 predicts system was considerably longer than the previous 7094 predict system. For these reasons, the AFETR, declared prime for the launch

phase, generated and transmitted to the stations sets of preflight nominal launch predicts.

Cooperation from the Project Telecommunications Analyst was excellent through the entire launch phase and the predict support provided by RTCS was flawless, so that initial acquisition was smooth with only a +375 Hz at S-band error in the one-way frequency. Initial uplink caught the spacecraft receiver on the first sweep, and the first good two-way doppler data were taken on schedule at L + 1 h and 7 min. First good ranging acquisition occurred at L + 2 h and 46 min.

Providing tracking data to NAV was a major problem in most of the prelaunch testing because of software problems and systems reliability. In light of this, a backup configuration for generating tracking data tapes on the 7094 system for use by the NAV area was put into effect. This backup effort worked smoothly during the launch phase. The backup production of tracking data tapes on the 7094 system was discontinued at approximately L + 8 h as the 360 data tape production system was deemed to be operating successfully. Project tape production continued to go very well during the period from launch until the first trajectory correction maneuver. Almost every tape was provided on time, and only a few minor frequency errors occurred, which were quickly corrected when discovered. Tape handling provided another source of minor problems that continued during the phase before the first trajectory correction phase. The following MDR tapes were written during this phase:

MDR Tape No.	Period covered
5481	Day 150 - 152/01:30
4994	Day 152/01:30 - 156/06:21

In summary, the NAV area was satisfied with DSN interface performance and Project data tapes.

d. First trajectory correction maneuver. Motor vent and unlatch were uneventful and could be observed in the pseudoresidual output (a comparison of actual incoming data with the tracking predictions). Since the new 360 software did not provide a plotting capability, an effort was made by TRAG to hand-plot pseudoresidual output under hard copy camera. Magnitudes of expected doppler shifts for roll and yaw maneuvers and main motor burn were +028, -0.089, and +96.428 Hz, respectively. Yaw maneuver and the main motor burn were plotted. Yaw maneuver was distinctly visible in the plotted data, while midcourse plot dramatically demonstrated successful and very accurate execution of the burn just a few seconds behind real time. The plot is shown in Fig. 70.

Tracking data taken during the Mariner 9 phase before the first trajectory correction were of the highest quality seen in any mission to date.

Significant problems during this period were a pass of DSS 12 ranging data that were bad, and several of early DSS 51 passes that had excessively high ranging noise. Both problems were isolated to equipment.

Minor problems noted were a very slight degradation of DSS 41 doppler data caused by a rubidium standard with higher than average noise (but well within specifications), and a slight angle-hitching problem in the DSS 51 antenna.

Extensive quantity and quality of doppler and ranging data, coupled with new orbit software that can consistently handle both data types, led to a far more rapid stabilization of NAV orbit determination solutions than on any previous Marine mission.

e. Real-time operations. Many procedures were revised with the actual mission experience. Until the Model 2 cruise, software was extremely unreliable and troublesome; yet operations did smooth out much more rapidly than expected. Necessary ranging data analysis training, although extensive, was successfully accomplished.

Two minor problems that continued to occur during the Mariner 9 phase before the first trajectory correction maneuver were (1) frequency errors in the manual inputs to the tracking software and (2) errors associated with the extensive volume of tape handling.

5. Command System. Command System support for Mariner 9 is discussed below.

a. General description of new capabilities. Prime characteristic of the DSN Command System, used for support of MM '71, was the capability for the Project to enter command data in the SFOF MSA and transmit data via HSDL to a DSS for subsequent transmission to the spacecraft. To provide this capability, the DSN underwent extensive development. The SFOF provided data entry devices, data validity checks, HSD block formatting, and displays of outgoing and incoming Command System data. The DSS accepted the command data, stored the data, transmitted the data to the spacecraft at the appropriate time, transmitted confirmation messages to the SFOF, and provided for system alarms. Multi-mission command system equipment was provided by the DSIF with the MM '71 Project the first user. In addition to the Project-supplied capabilities, DSN personnel exercised control over this equipment via HSDL from the SFOF.

These new capabilities provided many advantages over command systems previously used by the DSN in support of flight project commanding. Principal advantages were the following:

(1) Direct entry of data into the DSN command system by flight project personnel.

(2) Rapid spacecraft commanding because of automatic validity checks, verification, and confirmation.

(3) Ability to store command sequences at a DSS from the SFOF.

(4) Ability to control configuration of multiple mission equipment from the SFOF.

b. Mariner 9 command activity. Although the DSN Command System was not used as heavily as planned for later periods of the mission, critical periods of command activity did occur during the first week of the mission. The first command to the spacecraft from a DSS occurred at

approximately 17 min into the flight. A DC-9 was transmitted to the spacecraft from DSS 51 to turn ranging on. At approximately 3 h after launch, a DC-21 was transmitted from DSS 51 to perform a roll search to acquire Canopus. At approximately 24 h into the mission, a DC-45, followed by a DC-17, was transmitted to the spacecraft for platform unlatch and Canopus cone step, respectively. Following the DC-17, the first spacecraft CC&S update occurred. On Day 154, 4 days into the launch, 40 commands were transmitted from DSS 41 to Mariner 9 to update the CC&S for the first trajectory correction maneuver. On the following day, commands were transmitted to the spacecraft to accomplish the maneuver.

6. Monitor System. Monitor System support for Mariner 9 is discussed below.

The DSN Monitor System is a mission-independent system providing capability for sensing certain characteristic elements of the DSN.

Monitor data are used to determine DSN status and configuration, for processing and displaying data for use by DSN operations, for providing guidance in directing DSN operations, and for unofficial analysis of quality and quantity of data provided to the Project.

Monitor System software was not complete to fully support the DSN as originally designed. One feature most needed, but noticeably missing, was the automatic alarm portion of the Monitor Processor. This portion of the software was, especially during the cruise phase, to have the capability to alarm all nonstandard conditions throughout the DSN.

For the deep space phase of the mission, the Monitor System developed formats that were output on DTV. These formats were processed through the Monitor Processor, extracted from the various data streams, converted to engineering units, and formatted for display to the operations personnel. Operations personnel used these formats to determine, in real time, the DSN status and the quantity and quality of data provided to the Project. In addition, monitor personnel were responsible for providing data to Operation Data Control (ODC) in the form of pass folders. The personnel also provided a weekly report on DSN performance in the form of a graph showing frequency and the variation of DSN parameters from a gross facility point of view.

Table 49. Mariner 8 countdown summary

Event	Time (T)	GMT
Start Range Countdown	T-335	1826
Start GSFC Network Countdown	T-331	1830
AO/MOC Manned and Operational	T-230	2011
Start Spacecraft Countdown	T-210	2031
Start 60-Minute Built-In Hold	T-90	2231
End of BIH; Resume Count	T-90	2331
Start 10-Minute Built-In Hold	T-10	0051
End Built-In Hold; Resume Count	T-10	0101
Liftoff	T-0	0111

Table 50. Mariner 8 summary of observed mark events

Mark Event No.	Mark Event	Nominal Time L+sec	MIL USB Observed GMT (L+sec)	Bermuda Observed GMT (L+sec)	AFETR Observed GMT (L+sec)
-	Liftoff 5.08-cm (2-in.) motion	-	-	-	0111:02.294
1	Atlas BECO	147.86	0113:31.3 (149.01)		0113:31.3 (149.01)
2	Atlas Booster Engine Jettison	150.97	0113:34.2 (151.91)		0113:34.3 (152.01)
3	Centaur Insulation Panel Jettison	192.87	0114:16.2 (193.91)		-
4	Nose Fairing Jettison	234.87	0114:58.1 (235.81)		-
5	SECO	250.89	0115:14.9 (252.61)		0115:15.3 (253.01)
6	Atlas/Centaur Separation	252.89	0115:17.6 (255.31)		0115:18.8 (256.51)
7	Centaur Main Engine Start	262.39	0115:28.1 (265.81)	0115:28.2 (265.91)	
8	Centaur MECO	715.36	0116:56.1 (353.81)	0116:56.0 (353.71)	0116:57.5 (355.21)
			0117:05.4 (363.11)	0117:50.5 (363.21)	0117:06.5 (364.21)
			0117:41.4 (399.11)		0117:42.5 (400.21)
					0117:48.0 (405.71)
					0117:51.0 (408.71)
9*	Separate S/C	810.36			
10*	Reorient Centaur to Deflection Vector	1270.36			
11*	Start Blowdown	1715.36			
12*	End Blowdown	1965.36			
13*	Power Changeover	1965.36			

*Mark events 9 through 13 not observed.

Table 51. Mariner 8 loss-of-modulation report

Station	Loss of Modulation 9 May 1971 (GMT)
MIL USB	0116:54.0
CIF	0116:53.4
ANTIGUA	0116:53.0

Table 52. Near-Earth TDS station coverage

Coverage	Station*	Interval (sec)**
C-Band Tracking	1.16	0 - 387
	19.18	10 - 487
	0.18	24 - 509
	3.13	86 - 522
	BDA FPQ-6	292 - 556
	BDA FPS-16	256 - 556
	91.18	402 - 555
Centaur Telemetry	GBI	60 - 528
	GTK (TAA-8)	188 - 553
	GTK (TAA-3)	178 - 553
	ANT (TAA-8A)	408 - 480
	ANT (TAA-3A)	428 - 480
	MIL (USB)	-122 - 466
	BDA	244 - 552
Mariner Telemetry	DSS 71	Minus Ct. - 514
	MIL (USB)	-122 - 514
	BDA	268 - 552
	ANT (TAA-8A)	347 - 493
	ANT (TAA-3A)	429 - 493

*All stations reported fluctuating signals; tracking at the 91.18 did not break 1.5 deg elevation.

**Represent usable data interval.

Table 53. Mariner 9 countdown summary (May 29, 1971) (in minutes)

Event	Time (T)	GMT
Start Range Countdown	T-335	1536
Start GSFC Network Countdown	T-331	1540
AO/MOC Manned and Operational	T-230	1721
Start Spacecraft Countdown	T-210	1741
Start 60 Minute Built-In Hold	T-90	1941
End of Built-In Hold; Resume Count	T-90	2041
Unscheduled Hold-Auto Pilot Tests	T-72	2059
Test Terminated	T-72	2205

Table 54. Mariner 9 countdown summary (May 30, 1971) (in minutes)

Event	Time (T)	GMT
Start Range Countdown	T-335	1532
Start GSFC Network Countdown	T-331	1536
AO/MOC Manned and Operational	T-230	1717
Start Spacecraft Countdown	T-210	1737
Start 60-Minute Built-In Hold	T-90	1937
End of Built-In Hold; Resume Count	T-90	2037
Start 10-Minute Built-In Hold	T-10	2157
End of Built-In Hold; Resume Count	T-10	2207
Unscheduled Hold - Atlas PU Problem	T-4:30 (Recycle to T-5)	2212:30
Resume Count	T-5	2218
Liftoff	T-0	2223

Table 55. AFETR/MSFN launch phase tracking support for Mariner 9

Station	AOS	LOS	Comments
Merritt Island	150/2223:04	150/2231:50	-
Stadan AE	150/2223:04	150/2229:04	-
Bermuda	150/2226:43	150/2234:32	-
Antigua	150/2228:50	150/2235:14	-
Vanguard (ship)	150/2232:55	150/2242:49	(Dropout 2236:47 to 2237:35)
ARIA (aircraft)	150/2233:18	150/2246:29	-
Canary Island	150/2237:55	150/0042	(released)
Ascension (MSFN)	150/2239:32	151/0934	-
Ascension (AFETR-12)	150/2239:41	150/2326:34	(released)

Table 56. Mariner 9 summary of observed mark events

Mark Event No.	Mark Event	Nominal Time L+sec	MIL USB Observed GMT (L+sec)	Bermuda Observed GMT (L+sec)	AFETR Observed GMT (L+sec)
-	Liftoff 5.08-cm (2-in.) motion				2223. 04. 463
1	Atlas BECO	147. 86	22:25:35. 5 (151. 04)		2225:35. 55 (151. 09)
2	Atlas Booster Engine Jettison	150. 97	22:25:38. 5 (154. 04)		2225:38. 5 (154. 04)
3	Centaur Insulation Panel Jettison	192. 87	22:26:20. 5 (196. 04)		
4	Nose Fairing Jettison	234. 87	22:27:02. 6 (238. 14)		
5	SECO	250. 89	22:27:07. 5 (243. 04)		2227:08. 4 (243. 94)
6	Atlas/Centaur Separation	252. 89	22:27:10. 5 (246. 04)		2227:11. 6 (247. 14)
7	Centaur Main Engine Start	262. 39	22:27:20. 9 (256. 44)	22:27:21. 2 (256. 74)	
8	Centaur MECO	714. 68		2234:46. 9 (702. 44)	2234:47. 1 (702. 64)
9	Separate S/C	809. 68		2236. 22. 6 (798. 14)	
10	Reorient Centaur to Deflection Vector	1269. 68		22:44:03. 6 (1259. 14)	2244:02. 75 (1258. 29)
11	Start Blowdown	1714. 68		22:51:27. 1 (1702. 63)	
12	End Blowdown	1964. 68		22:55:37. 5 (1953. 04)	
13	Power Changeover	1964. 68		22:55:38. 1 (1953. 64)	

Table 57. RTCS orbital computations

Parameters		Transfer Orbit (Based on Vanguard Data)	Transfer Orbit (Based on Ascension Data)	Spacecraft Orbit (Based on DSS 51 Data)	Centaur Post Deflection Orbit) Based on Ascension Data)
Epoch Time (GMT, hr, min, sec)		22 34 59.6	22 34 59.6	23 24 59.9	22 56 40.0
Earth Fixed Sphericals	Radius(km)	6548. 2251680	6545. 36255320	22434. 20126300	12204. 07424250
	Latitude	22. 10574591	22. 11294330	-23. 65996240	-13. 84881424
	Longitude	311. 21507988	311. 20191390	39. 11714381	20. 16636164
	Velocity km (sec)	11. 02673176	11. 02750158	6. 11336960	8. 08544295
	Path Angle	0. 44171786	0. 65153350	71. 34965280	48. 46086595
	Azimuth Angle	109. 70271293	109. 68277217	119. 90336978	119. 73720929
Eccentricity		1. 1515648	1. 1508412	1. 1504343	1. 1450878
Inclination		28. 8072085	28. 8007665	28. 8313101	28. 9914118
C3		9. 2256950	9. 1862170	9. 1620562	8. 8435537
Time of Computation (min)		24	58	258	88
Quality of Solution		Poor	Fair	Fair	Fair

Table 58. Mariner 9 pass chronology, Pass 1 through Pass 7

Pass 1 (Launch), May 30/31, 1971 (Day 150/151)

DSS 71 AOS 150/2223:04; LOS 150/2231; Commands Transmitted - 0

Deviations or Anomalies

None

DSS 51 AOS 150/2246; LOS 151/0855; Commands Transmitted - 3; Ranging - Limited.

Deviations or Anomalies

1. DSS - Station experienced numerous problems in obtaining good ranging data, caused partially by procedural errors and partially by hardware failures. Following replacement of the 496 kHz distribution amplifier in the ranging subsystem, one good ranging code acquisition was accomplished at approximately 0010: It was not repeatable until transmitter power (SAA Antenna) was raised from 100W to 10 KW. At that time, the ranging code was reacquired, and several good ranging data points were obtained, although the ranging residuals indicated excessive noise. A two-way transfer from DSS 51 to DSS 62 was performed at approximately 0310 to provide good ranging data. DSS 51 performed additional tests on their ranging subsystem. At approximately 0535 a two-way transfer was performed from DSS 62 back to DSS 51. However, no good two-way ranging data were obtained from DSS 51 before transfer to DSS 12. The ranging subsystem problem remained under investigation following end-of-track (EOT) (Ref. DR 01220).

DSS 62 AOS 151/0050; LOS 151/0830:34; Commands Transmitted - 0; Ranging - Mark IA.

Deviations or Anomalies

None

DSS 12 AOS 151/0755; LOS 151/1626; Commands Transmitted - 0; Ranging - Mark IA.

Deviations or Anomalies

1. DSS - Station was unable to perform ranging from AOS to 1431 because of TDH subsystem problems (Ref. DR 01221).
2. CPS - 360/75 computer system switched (B to A) from 1045 to 1053 because of main adder Central Processing Unit (CPU) checks on 360/75B (Ref. DR 1544).

DSS 14 AOS 151/0909; LOS 151/1610; Commands Transmitted - 0; Ranging - TAU-R & D.

Deviations or Anomalies

1. DSS - AOS was delayed approximately 30 minutes because of hydrostatic bearing, pump problems (Ref. DR 01222).

DSS 41 AOS 151/1325; LOS 152/0225; Commands Transmitted - 1; Ranging - Mark IA.

Deviations or Anomalies

1. CPS - 360/75 computer down for reload from 1500 to 1520 because of Input/Output (I/O) errors causing system fault (Ref. DR 1546).

Pass 2, May 31/June 1, 1971 (Day 151/152)

DSS 51 AOS 151/2103; LOS 152/0900; Commands Transmitted - 25; Ranging - No.

Deviations or Anomalies

1. DSS - Ranging subsystem down entire tracking period. Cause remains under investigation (Ref. DR 01224).
2. CPS - CDC 3100 computer (Digital TV (DTV), data display buffer) down from 0241 to 0310. Required several restarts and reloads in order to obtain a continuous active status (Ref. DR 1549).
3. CPS - 360/75 reloaded from 0315 to 0330, because of operator I/O lockout and inability to perform a required restart (Ref. DR 1551).

DSS 12 AOS 152/0806; LOS 152/1551; Commands Transmitted - 0; Ranging - Mark IA.

Deviations or Anomalies

1. CPS - 360/75 down for restart from 0905 to 0913, because of formatted telemetry data output halt caused by MSA DISC-pack error (Ref. DR 1553).
2. CPS - 360/75 down for restart with dump from 1412 to 1425, because of Pseudo-Residual Program halt (Ref. DR 1554).
3. CPS - 360/75 down for restart with dump from 1446 to 1458, because of formatted telemetry data output halt and Pseudo-Residual Program halt (Ref. DR 1557).

DSS 14 AOS 152/0846; LOS 152/1623; Commands Transmitted - 0; Ranging - TAU - R & D.

Deviations or Anomalies

1. DSS - Antenna went to brake and off-point with receiver out-of-lock from 1505 to 1526. Cause of problem was not determined before EOT (Ref. DR 01228). Station was acquiring R & D ranging data and DSS 12 was prime on telemetry. Approximately 21 minutes of two-way ranging data were lost.

DSS 41 AOS 152/1322; LOS 153/0210; Commands Transmitted - 1; Ranging - Mark IA.

Deviations or Anomalies

None

Table 58 (contd)

Pass 3, June 1/2, 1971 (Day 152/153)

DSS 51 AOS 152/2105; LOS 153/0902; Commands Transmitted - 0; Ranging - No.

Deviations or Anomalies

1. DSS - Ranging subsystem down throughout entire track. Problem remains under investigation (Ref. open DR 01224).

2. GCF - High-speed-data-line (HSDL) up and down from 0140 to 0207, because of excessive line noise from Johannesburg communications link. Cause was not determined (Ref. DR 2578). CPS telemetry data process was switched back to DSS 41 during DSS 51 HSDL outage (possible because of track overlaps).

3. GCF - HSDL down from 0816 to 0843. Cause was not determined (Ref. DR 2581). CPS telemetry data process was switched to DSS 12 at 0821 (again possible because of track overlaps).

DSS 12 AOS 153/0803; LOS 153/1640; Commands Transmitted - 0; Ranging - Mark IA.

Deviations or Anomalies

None

DSS 14 AOS 153/0847; LOS 153/1626; Commands Transmitted - 0; Ranging - TAU - R & D.

Deviations or Anomalies

None

DSS 41 AOS 153/1322; LOS 154/0208; Commands Transmitted - 1; Ranging - Mark IA.

Deviations or Anomalies

None

Pass 4, June 2/3, 1971 (Day 153/154)

DSS 51 AOS 153/2100; LOS 154/0902; Commands Transmitted - 0; Ranging - No.

Deviations or Anomalies

1. DSS - Ranging subsystem still down throughout tracking period. Cause remains under investigation (Ref. open DR 01224).

2. CPS - 360/75 down for reload from 0727 to 0741, because of abnormal endings of the real-time monitor data format processor (Ref. DR 1574).

3. GCF - HSDL inbound to SFOF was garbling from 0742 to 0748, because of a bad link via Ascension Isl. HSDL was made good via Canary Isl. (Ref. DR 2589).

DSS 12 AOS 154/0810; LOS 154/1639; Commands Transmitted - 0; Ranging - Mark IA.

Deviations or Anomalies

None

DSS 41 AOS 154/1310; LOS 155/0201; Commands Transmitted - 40; Ranging - Mark IA.

Deviations or Anomalies

1. GCF - HSDL down from 0016 to 0027, because of a circuit failure between the DSS and Canberra NASCOM (Ref. DR 2559). The CPS high speed data (HSD) process was switched to DSS 51, 0021 to 0029 to provide real-time data during DSS 41 HSDL outage.

2. GCF - HSDL down 0057 to 0106. Cause was not determined (Ref. DR 2600). CPS HSD process was switched to DSS 51 at 0059 and remained on DSS 51 through DSS 41 LOS.

Pass 5, June 3/4, 1971 (Day 154/155)

DSS 51 AOS 154/2058; LOS 155/0856; Commands Transmitted - 0; Ranging - No.

Deviations or Anomalies

1. DSS - Ranging subsystem still down throughout tracking period. Cause remains under investigation (Ref. open DR 01224).

DSS 12 AOS 155/0832; LOS 155/1634; Commands Transmitted - 0; Ranging - Mark IA.

Deviations or Anomalies

1. DSS - AOS was delayed approximately 30 minutes because of problems with command data transfer test caused by an apparent TCP/DIS interface anomaly. Numerous TCP reloads and DIS reloads were performed before the command data transfer test could be completed. The Command System was declared green at 1059. The actual cause of the TCP/DIS interface problem was not determined in real time (Ref. DR 01234).

DSS 41 AOS 155/1322; LOS 156/0203; Commands Transmitted - 20; Ranging - Mark IA.

Deviations or Anomalies

Pass 6, June 4/5, 1971 (Day 155/156)

DSS 51 AOS 155/2046; LOS 156/0853; Commands Transmitted - 0; Ranging - No.

Deviations or Anomalies

1. DSS - Ranging subsystem still down throughout tracking period. Cause remains under investigation (Ref. open DR 01224).

2. DSS - Station was unable to turn on transmitter for two-way transfer from DSS 41 at 0130. DSS 41 remained two-way and CPS HSD process remained on DSS 41 to DSS 41 LOS. DSS 51 resolved their transmitter problem and obtained two-way lock at 0235. The transmitter problem was caused by a faulty RF switching relay (Ref. DR 01235).

3. CPS - 360/75 down for restart from 0726 to 0731 because of excessive backlog on telemetry processor. 360/75 was restarted again from 0735 to 0738 because of a bad card deck load on previous restart (Ref. DR 1592 and DR 1594).

DSS 12 AOS 156/0803; LOS 156/1632; Commands Transmitted - 0;
Ranging - Mark IA.

Deviations or Anomalies

1. DSS - Station was unable to complete command data transfer test until 0830 because of apparent TCP/DIS interface problem. Cause of problem remains under investigation (Ref. Open DR 01234).

DSS 14 AOS 156/0843; LOS 156/1618; Commands Transmitted - 0;
Ranging - TAU-R & D.

Deviations or Anomalies

None

DSS 41 AOS 156/1321; LOS 157/0154; Commands Transmitted - 1;
Ranging - Mark IA.

Deviations or Anomalies

None

Pass 7, June 5/6, 1971 (Day 156/157)

DSS 51 AOS 156/2045; LOS 157/0849; Commands Transmitted - 0;
Ranging - Limited.

Deviations or Anomalies

1. DSS - Ranging subsystem still considered down (Ref. open DR 01224). Some ranging data were obtained between 2100 and 157/0600; however, ranging residual data showed excessive noise.
2. GCF - HSDL was erratic both ways from 0242 to 0248. Cause was not determined (Ref. DR 2606).
3. CPS - CDC 3100 went down and required a switch from A to B computer from 0652 to 0700. The problem was apparently caused as a result of a scheduled 360/75 computer switch (B to A) that took place at 0648 (Ref. DR 1597).
4. CPS - 360/75 down for reload from 0711 to 0735 because of I/O errors (unable to control tape banks and would not respond to restart). Cause was apparently a program fault (Ref. DR 1596).
5. CPS - 360/75 down for restart with a disk-pack change from 0841 to 0850 because of Mission Support Area (MSA) disk-pack errors (Ref. DR 1598).

DSS 12 AOS 157/0801; LOS 157/1626; Commands Transmitted - 0;
Ranging - Mark IA.

Deviations or Anomalies

1. CPS - 360/75 formatted data outputs stopped from 0914 to 0924; cause unknown. Formatted data outputs resumed automatically.
2. CPS - 360/75 down for restart with dump from 0945 to 0948 because of formatted data output halt (Ref. DR 1599).

Table 58 (contd)

3. CPS - 360/75 down for restart from 0957 to 1000 because of formatted data output halt (Ref. DR 1600).
4. CPS - 360/75 down for reload from 1423 to 1431 because of telemetry process backlog caused by predict generation run (Ref. DR 1603).

DSS 41 AOS 157/1333; LOS 158/0157; Commands Transmitted - 3; Ranging - Mark IA.

Deviations or Anomalies

1. CPS - 360/75 down for reload from 1850 to 1858 because of system control I/O lockout (Ref. DR 1604).

Table 59. Mariner 9 downlink signal levels

Pass	DSS	Downlink, dbm	Predict, dbm	Residual, db
001	51	-109.8	-109.9	+0.1
	62	-112.9	-112.1	-0.8
	12	-118.1	-119.4	+1.3
	14	-113.8	-111.2	-2.6
	41	-121.3	-122.1	+0.8
002	51	-124.6	-125.5	+0.9
	12	-125.8	-127.4	+1.6
	14	-124.6	-119.4	-5.2
	41	-128.2	-128.7	+0.5
003	51	-129.8	-129.9	+0.1
	12	-129.5	-131.3	+1.8
	14	-122.8	-123.1	+0.3
	41	-131.6	-132.0	+0.4
004	51	-133.6	-132.8	-0.8
	12	-132.0	-133.7	+1.7
	41	-134.2	-134.2	0
005	51	-133.8	-134.7	+0.9
	12	-134.8	-135.4	+0.6
	41	-135.2	-135.8	+0.6
006	51	-136.1	-136.3	+0.2
	12	-136.8	-136.8	0
	14	-129.2	-128.6	-0.6
	41	-137.9	-137.1	-0.8

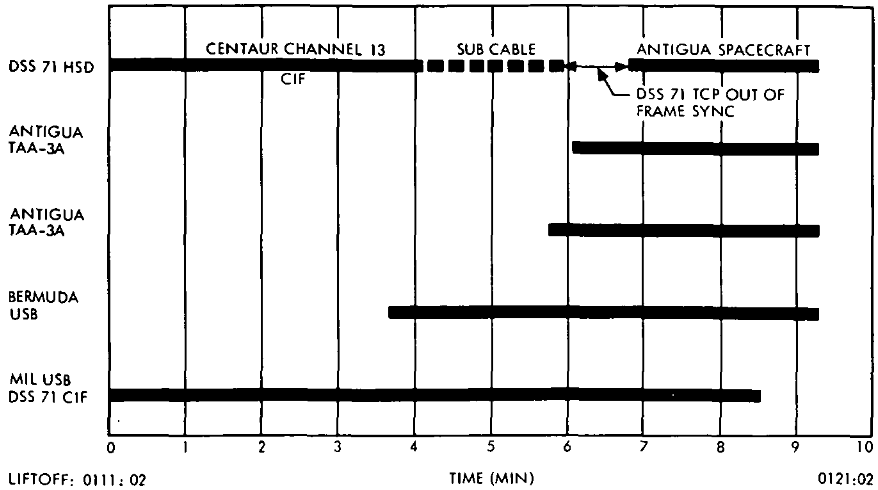


Fig. 59. Mariner 8 spacecraft telemetry coverage

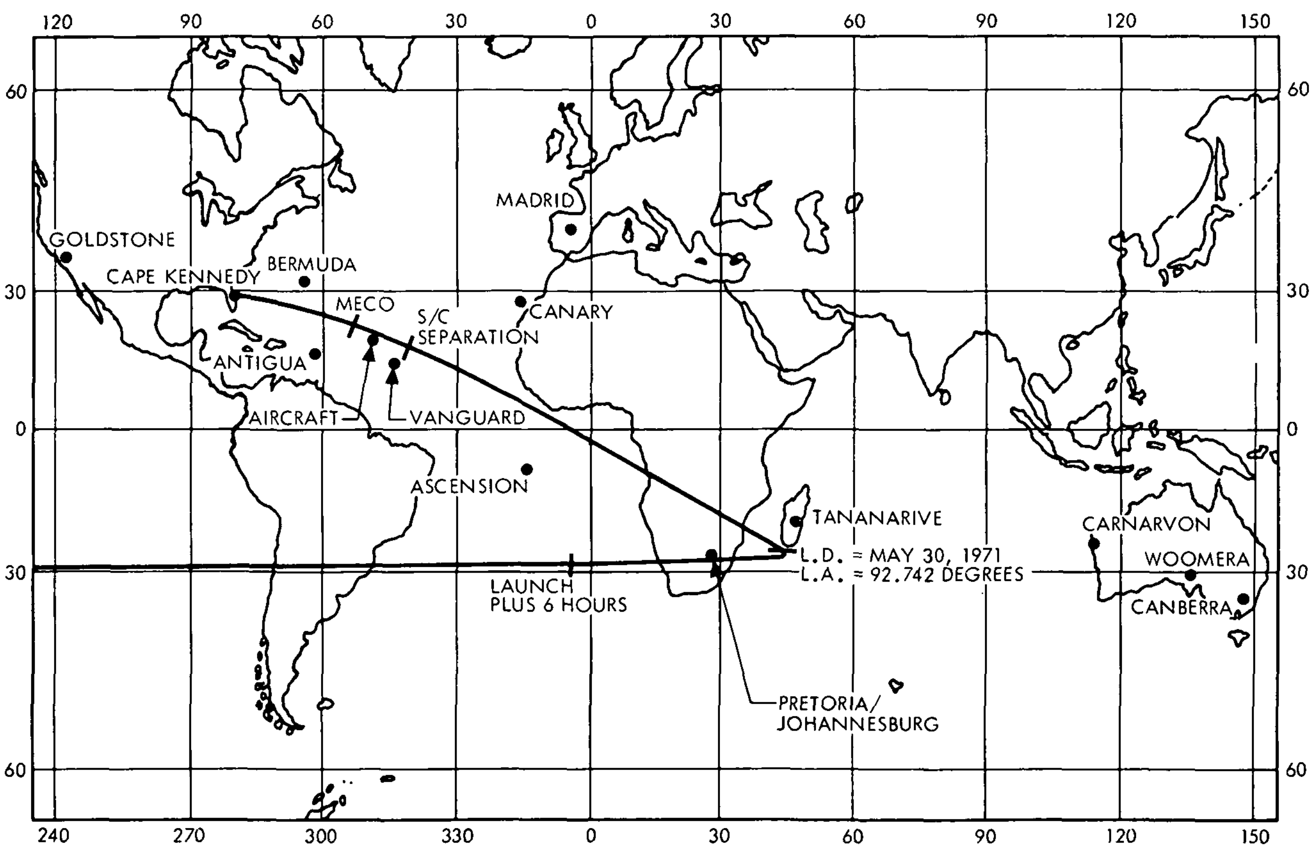


Fig. 60. Mariner 9 earth track for May 30, 1971, launch and Nov. 14, 1971, arrival

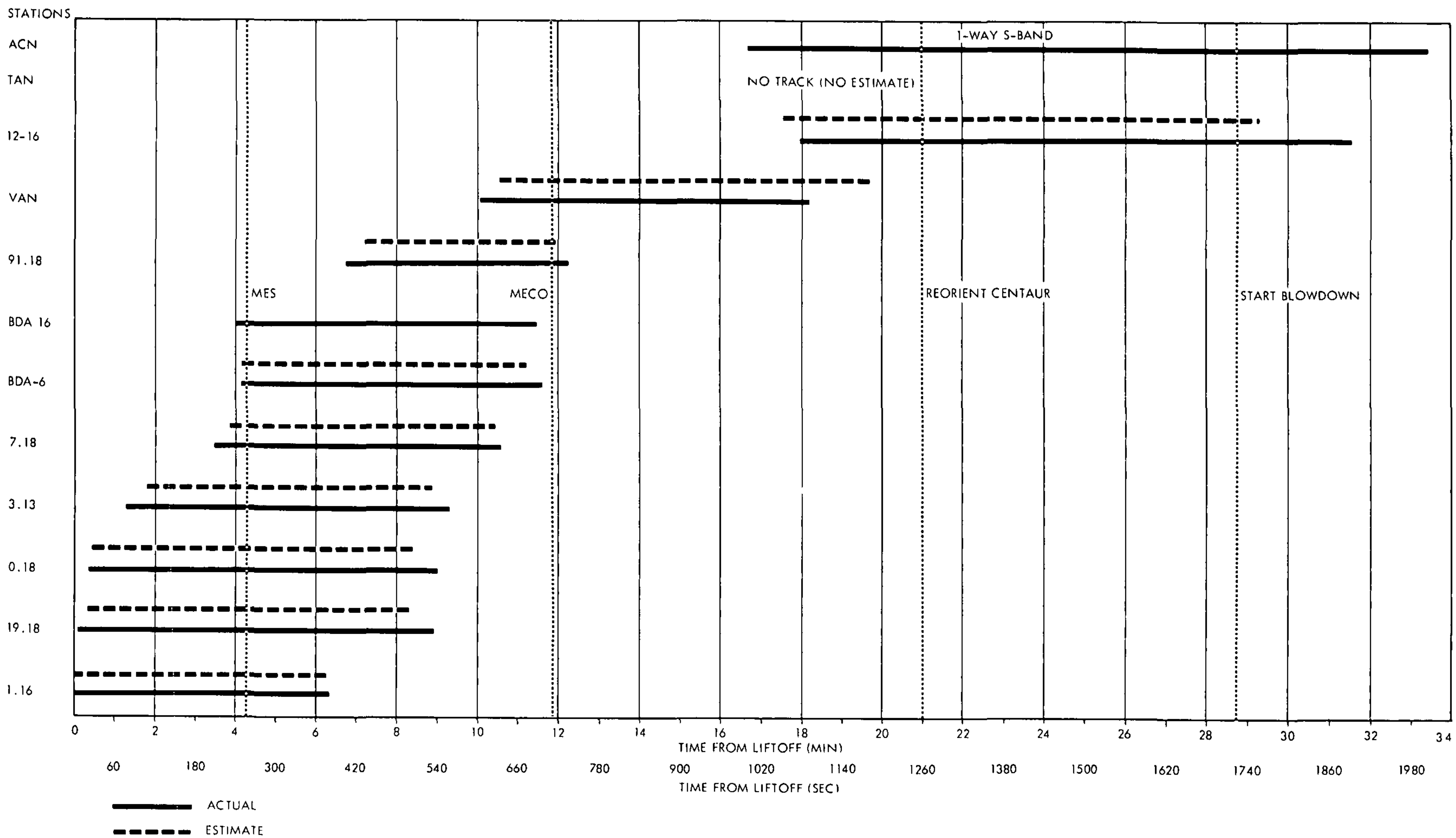


Fig. 61. Mariner 9 estimated and actual radar coverage

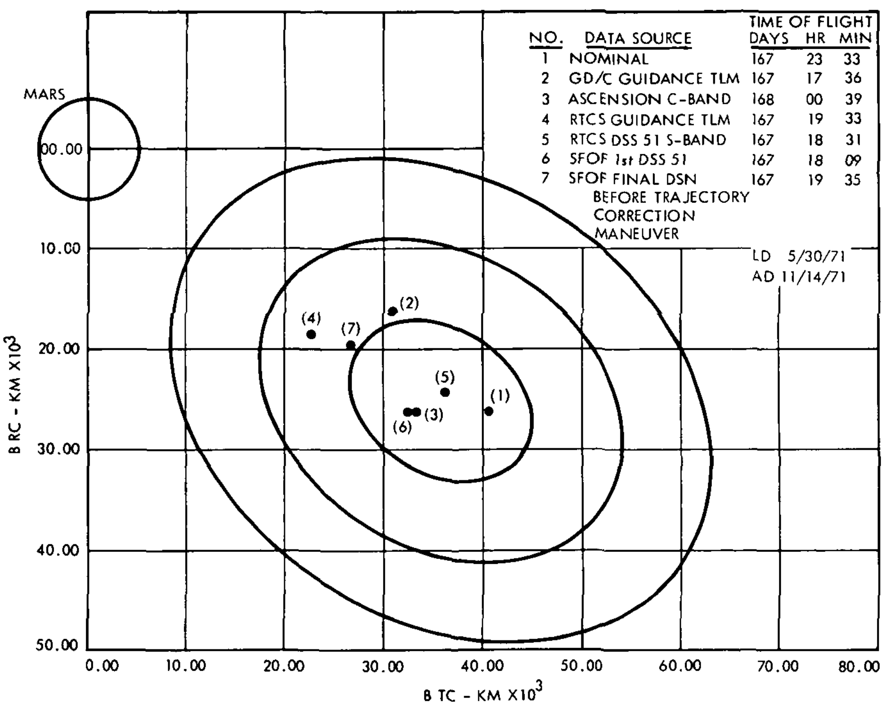


Fig. 62. Mariner Mars 1971 B-plane map

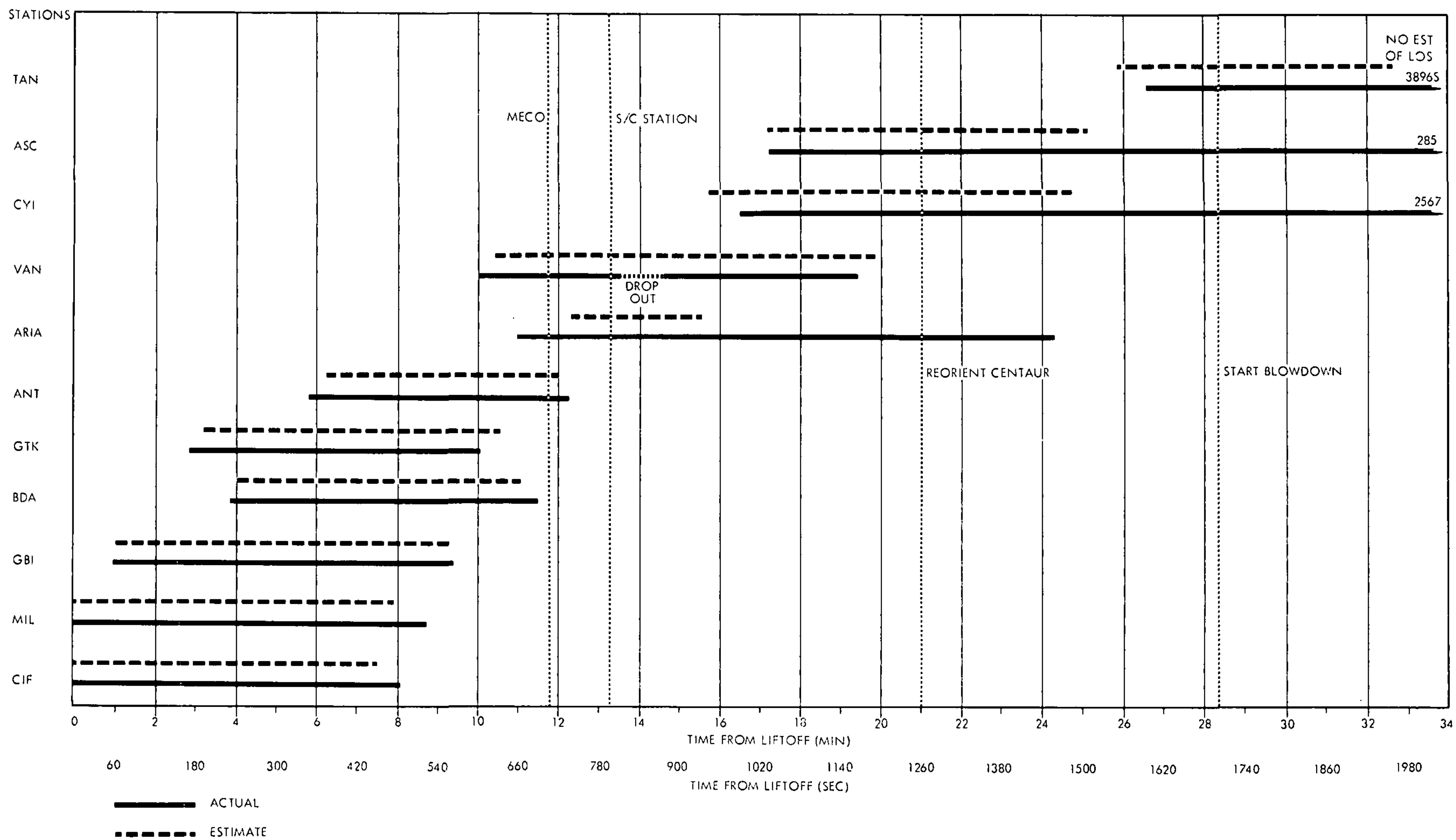


Fig. 63. Centaur telemetry coverage

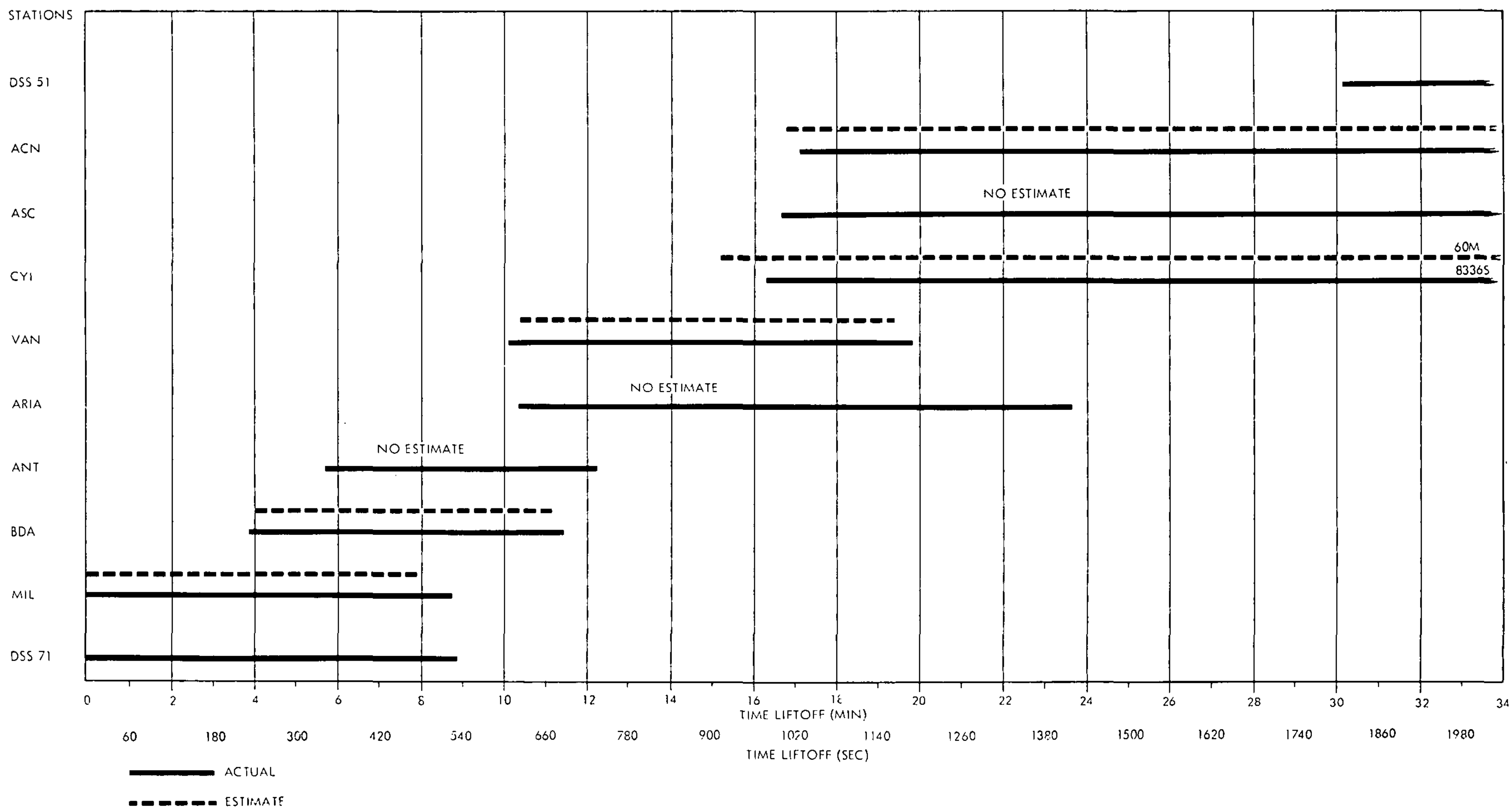


Fig. 64. Mariner 9 spacecraft telemetry coverage

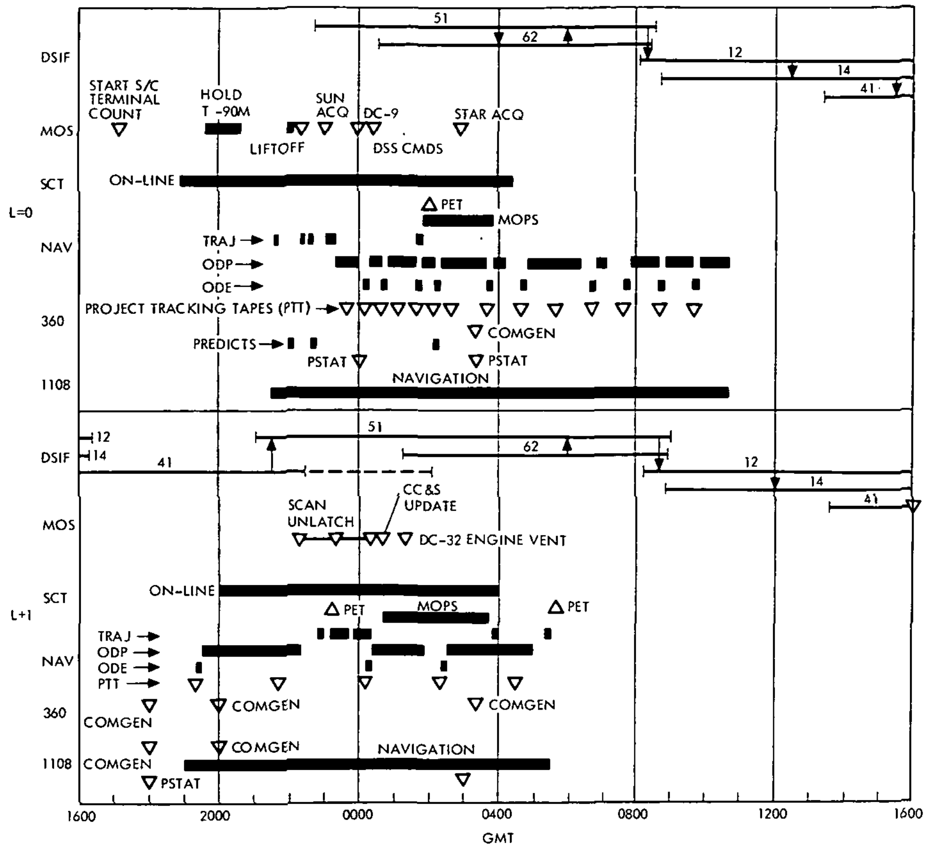


Fig. 65. Mission time lines, L = 0, T = 1

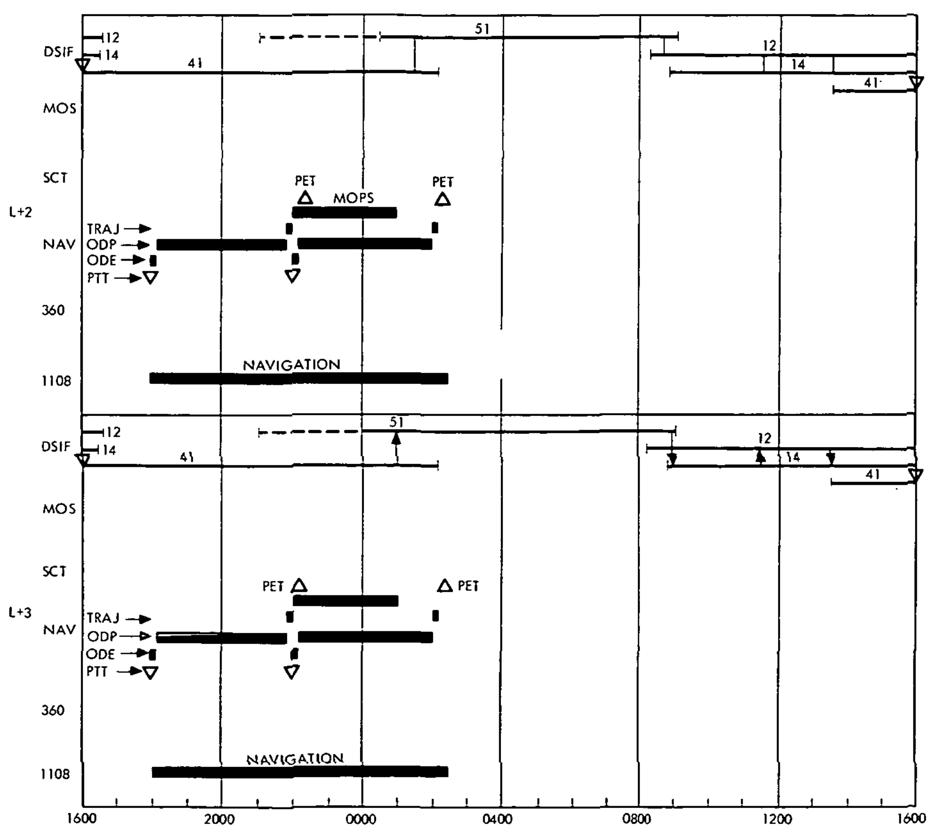


Fig. 66. Mission time lines, T = 2, T = 3

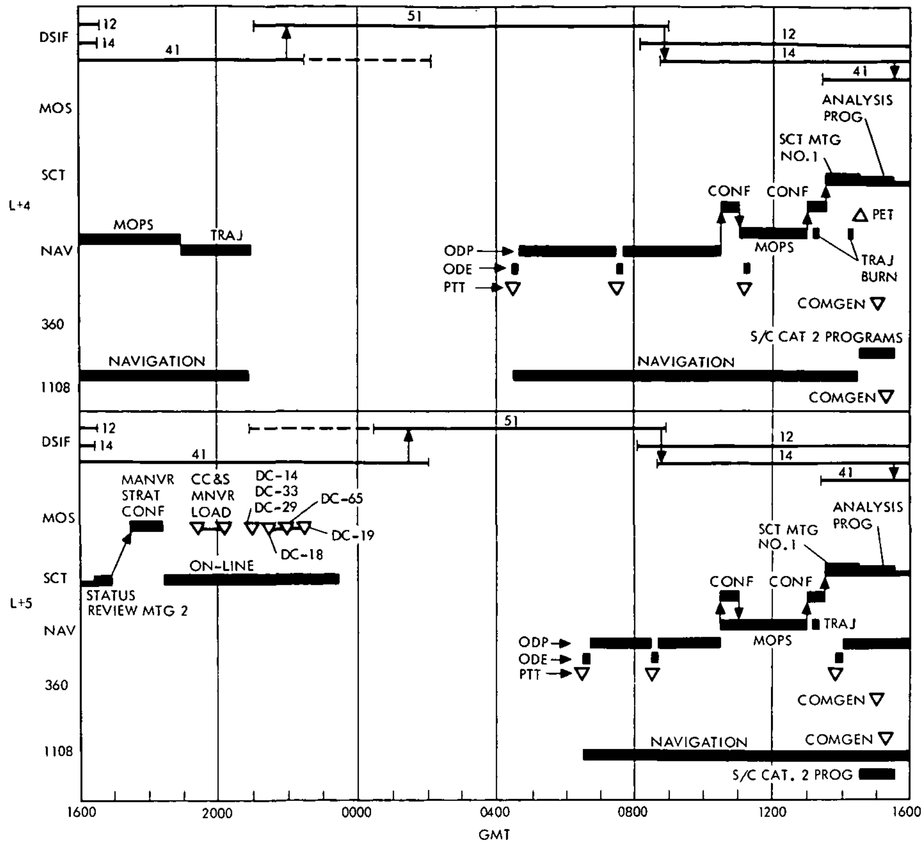


Fig. 67. Mission time lines, T = 4, T = 5

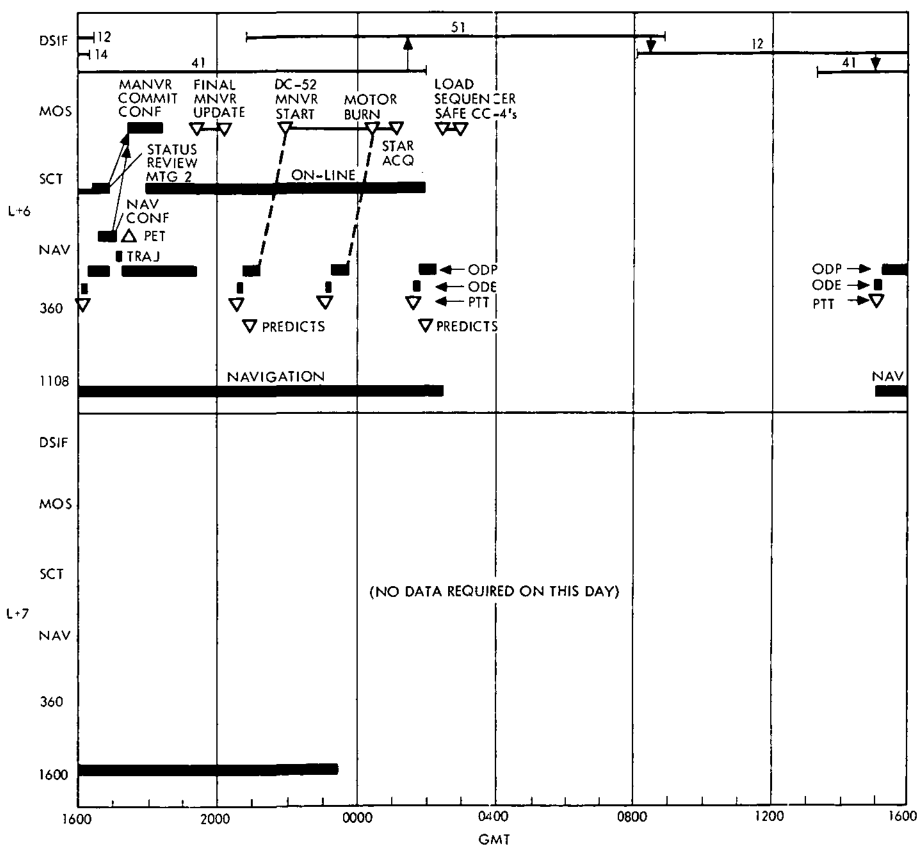


Fig. 68. Mission time lines, T = 6

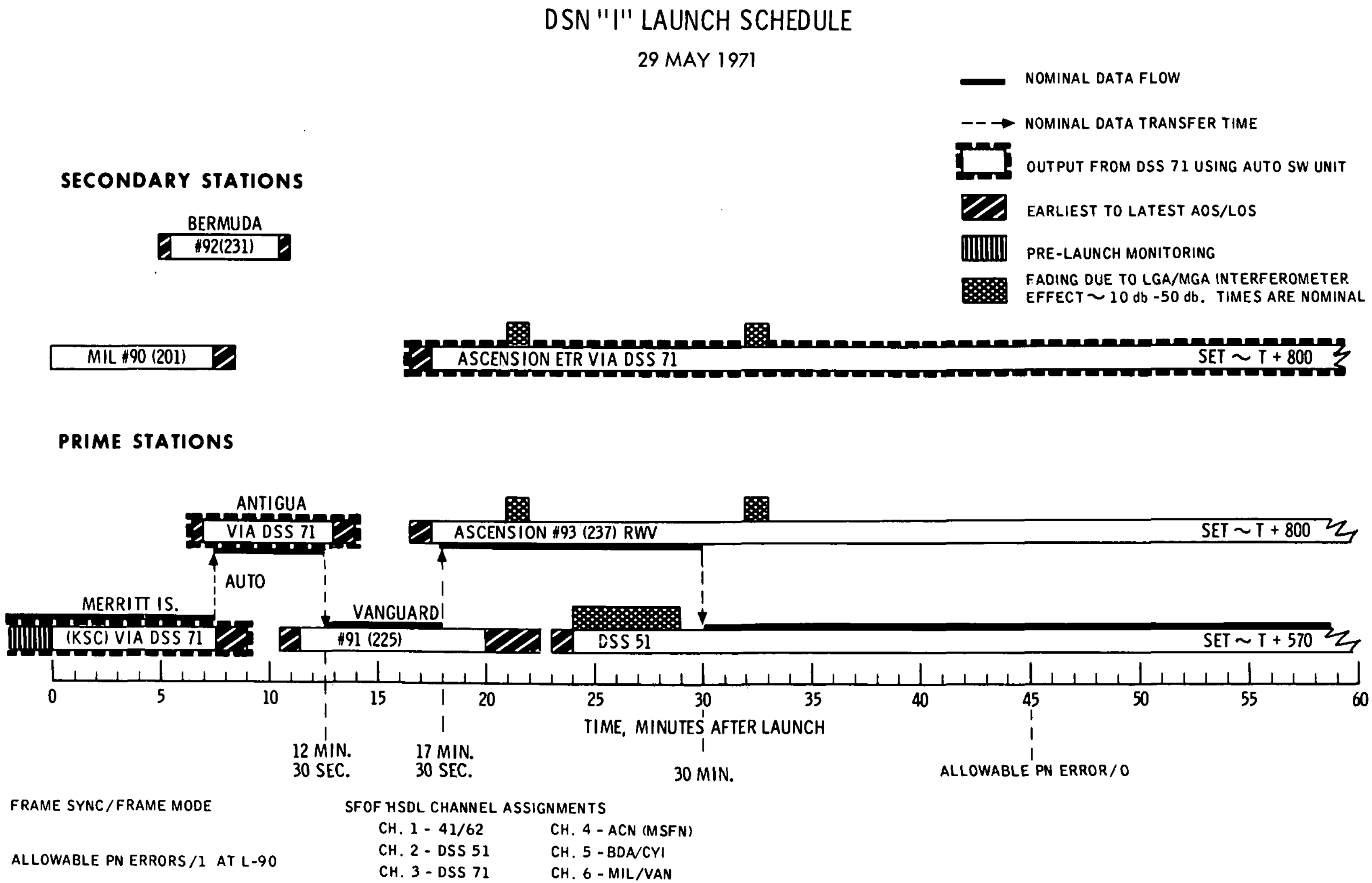


Fig. 69. Mariner 9 station coverage launch schedule

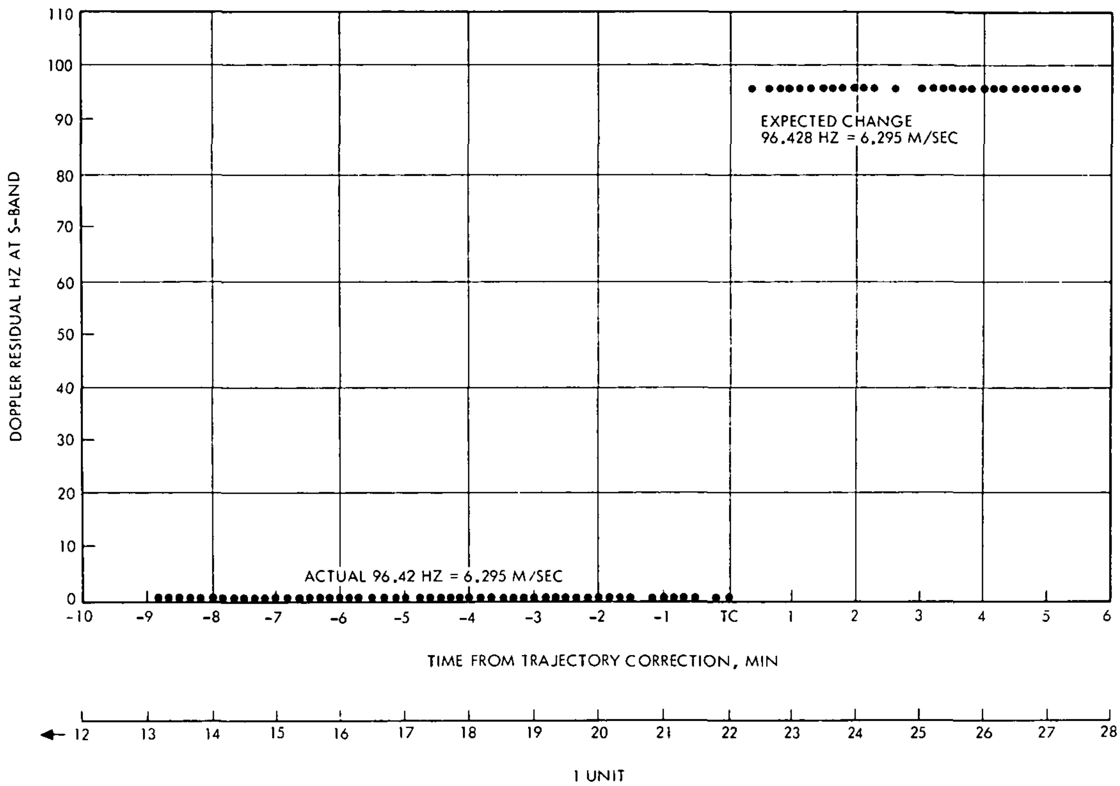


Fig. 70. Pseudoresidual output

VI. TDS PERFORMANCE EVALUATION, PRELAUNCH THROUGH FIRST TRAJECTORY CORRECTION MANEUVER

A. General

The performance evaluations in this Section are made by the appropriate member of the interface organization, supplemented by the evaluations of the DSN PE and DSN Manager.

B. Simulation System Operations

1. General. Simulation operations support began in July 1970 with a telemetry octal ID stream generated by the 6050 computer. Thirty hours of support to SFOF and DSIF development were supplied that month. By the time of the maneuver of Mariner 9, some 1500 hours of support had been supplied to the SFOF, DSIF, and MOS.

In the beginning, the software in the 6050 provided the capability for generating data from three DSSs. These three streams could contain data from two spacecraft. Command, monitor, display, and 1108 interface processors were added during the year of 1970 and Project MOS support began in January 1971 with the 1108 Math Model data being routed through the 6050 in the SIMCEN. By launch, some 1500 hours of support had been supplied to the SFOF, DSIF, and MOS as shown below:

SFOF/MK III	DSN OVT	MOS
560	660	320

2. Configuration vs reliability. The SFOF/DSN operational verification tests and the Project MOS tests are discussed below.

a. SFOF/DSN operational verification tests. The SFOF and DSN OVTs were generally conducted with few problems. These tests did not require the use of the 1108 interface, the 6050 overlay software, or leased printers. Normally, only command and telemetry generation (octal ID) were required. In this configuration, 6050 halts were rare and were invariably caused by hardware.

b. Project MOS tests. The MOS tests conducted with the Project involved the full operating system of the SIMCEN plus the 1108 Math Model. These tests were generally characterized by frequent 6050 halts.

3. Performance history. The performance history through the first trajectory correction maneuver is presented below.

a. July through December, 1970. During this period, the SIMCEN supported 190 h of SFOF development and 160 h of DSIF testing. Reliability was good during this period. At first the software used contained a telemetry generator responsive to manual inputs. In November a simple "turnaround" command program was added, together with a static data (manual input) monitor program. This capability was used until the end of 1970 with very few problems. During this period of July through December 1970, some 1200 h of SIMCEN development time were utilized to produce the interface with the 1108 and the overlay modules for command, tracking, display, and station data. Throughout this development period, as the 6050 became more and more laden with software functions and peripheral utilization, equipment problems arose with greater frequency, resulting in delay of software delivery. At the same time, discrepancies in the computer operation concerning peripheral utilization were encountered and were not identified as 6050 documentation discrepancies until some time in February 1971. This discrepancy directly affected the drum overlay routines.

b. January 1971 to first trajectory correction maneuver. During this period, the SIMCEN support was divided as follows (in hours):

MOS	360/MK III	DSN/DSIF	DEVEL	MAINT
320	370	498	1960	1810

The performance during this period was characterized by good support unless the user wanted to command the Math Model through the loop consisting of the 360, 6050, and the 1108. Tracking was done off line; i. e., it was generated on the 7094 and converted to paper tape, which was then played through the SIMCEN communication lines.

The Project MOS test configuration in January and February consisted of the Math Model running in real time in the 1108 with commands manually entered by the Project SIM team. Early tests were generally good until more display capability was added for the Project.

From that time on, reliability declined. It was improved with the finding of the 6050 documentation discrepancy mentioned earlier but then hardware problems with the leased display equipment began to crop up. These problems caused numerous computer halts. The contractor spent many hours researching the problem and treating the symptoms. Failures still occured but were minimized by software "work arounds" to force correct action of the equipment.

The addition of the command program to the 6050 brought new problems. Although the program was usable in a stand-alone mode for 360 software development, the program could not function properly with the Math Model.

The command program problem was caused by the original design, which was laid out under ground rules intended to get commands to the Math Model without the restriction of the 6050 simulating the action of the TCP. The redesign and re-coding was complicated by the fact that the programmer departed, and the fixes required amounted to an extensive redesign.

After the command program had been rewritten, problems were still experienced which caused program halts during maneuver tests. These were traced to the aforementioned 6050 documentation discrepancy and the software which stored the mass of 1108 data on the 6050 drum. After these problems were fixed, there still existed unexplained computer halts involving the

drum which were not resolved before launch and which caused repeated halts during tests which taxed the patience of all involved.

4. Simulation Conversion Assembly. The Simulation Conversion Assemblies located at the DSSs accepted the NASCOM formatted high speed data from the SIMCEN at the SFOF and converted the data to spacecraft rate and SCO frequency, then modulated this data on an S-band test transmitter for insertion into the DSS antenna.

These assemblies gave practically no trouble and were the most reliable assembly in the entire Simulation System. Only minor procedural problems were experienced and few hardware failures. Lack of automatic 6050 control of the SCA attenuators created some operational difficulties and lack of realism during maneuver sequences.

5. Summary. Four months before launch, the DSN SIMCEN was able to support three simultaneous tests: (1) An MOS short-loop test with the Math Model (commands manually input by project SIM personnel), (2) An SCA test with DSS 61, and (3) A 360 command test. None of these tests interfered with each other, although all were using the same computer (6050).

The addition of the interactive programs using the drum for display, the leased printers, passing commands to the 1108, and the station data generation all acting simultaneously created a complexity of hardware and software operation which resulted in degraded performance. The contributing factors to this degraded performance were:

(1) No machine backup in the SIMCEN.

(2) A heavily loaded SIMCEN schedule, which did not allow sufficient time for development and checkout.

(3) No capability for self test in the SIMCEN.

(4) The earthquake of Feb. 9, 1971. (The statistics show a sharp rise in corrective maintenance time since that event.)

In general, SIMCEN support of 360 development and test and support of the DSN operational verification tests with the stations were conducted with no problems. Problems that did develop were invariably concerned with hardware and not software. These tests did not require the simultaneous activity of the various 6050 software modules (command, telemetry, station data, and 1108 processor). However, whenever the full capability was energized as it was for checkout during some DSN operational verification tests and for all MOS tests, the system became unreliable. The user affected by this unreliability in every case was the MM '71 MOS.

C. Near-Earth TDS Performance Evaluation

1. Telemetry. Figure 71 summarizes Centaur telemetry data usability by representing percent usability (0-100) by Near-Earth TDS station coverage. The summary was prepared by the telemetry laboratory at KSC/ULO. From liftoff through T + 1420 s, Centaur data coverage was 100 percent. In addition, Tananarive data coverage was excellent.

The engineering test of receiving ARIA data in real time via satellite, GBI antenna, and submarine cable was a definite success. A brief analysis of real-time vs tape data was performed, and it appeared as if the real-time data were as good as the tape for that portion of the run for which real-time data were available. Real-time data should definitely be used in like situations in the future.

Aside from dropouts caused by signal fade, recovery of spacecraft data in real time from the Near-Earth TDS was good. DSS 71 was unable to achieve frame sync on the ARIA real-time data; this was attributed to the ARIA's use of manual track when autotrack was lost. The data flow test in the minus count was excellent.

2. Tracking. VAN low-speed metric data to the RTCS were rough but adequate for providing DSN predicts.

Results of a comparison of VAN HSD provided to the GSFC computer and the low-speed data provided to the RTCS showed no significant differences. Both had station location errors, and the real-time data results were based on tracking at low elevation angles using too few ranging points.

D. Deep Space Phase

The TDS performance was monitored daily by the Network Analysis Team. Results of the analysis were provided to the OCT to allow corrective action to be initiated when performance fell below predicted or committed levels; these results indicated that TDS performance was excellent through first trajectory correction maneuver.

1. Telemetry System. Overall performance of the DSN Telemetry System in support of Mariner 9, from launch through June 6, 1971, was nominal with no major problems encountered.

Residual data plots of SNR, uplink signal levels, and downlink signal levels for each station tracking Mariner 9 spacecraft during the period of June 16-29, 1971, are shown in Figs. 72 through 76. These data are presented for general information on Telemetry System performance, since the data cover a period a little later than launch through first trajectory correction maneuver. Values plotted were taken at meridian crossing for each pass. Data begin on Day 167 (June 16, 1971) to preclude erroneous readings from excessive signal strengths that have existed before that time. For this reason, no SNR readings are shown for DSS 14. The set of five plots represents those stations that actively participated in tracking the Mariner 9 spacecraft since Day 167 to the end of June. The number of days plotted varies from station to station as a function of individual station tracking schedule.

A statistical analysis on absolute data values yielded the following results:

(1) Signal-to-noise ratio. Plotted data contained 42 SNR readings that were found to have an arithmetic mean of 0.4583 dB and a standard deviation of 0.3748 dB. Of the observations, 90.48% were within 0.86 dB of the predicted values; the

value most often observed was less than 0.29 dB.

(2) Downlink signal level. Plotted data contained 46 downlink signal-level readings that were found to have an arithmetic mean of 0.6087 dB and a standard deviation of 0.5240 dB. Of the observations, 76.09% were within 0.90 dB of the predicted values; the value most often observed was less than 0.3 dB.

(3) Uplink signal level. Data plotted contained 46 uplink signal-level readings that were found to have an arithmetic mean of 0.6880 dB and a standard deviation of 0.7014 dB. Of the observations, 71.74% were within 0.91 dB of the predicted values; the value most often observed was less than 0.46 dB.

2. Tracking System support. Tracking System support is discussed below.

a. Initial acquisition. Cooperation from the Project Telecommunications Analyst was excellent through the entire launch phase, and the predicts support by the RTCS was flawless, so that initial acquisition went smoothly with only a +375 Hz error at S-band in the one-way frequency. Initial uplink caught the spacecraft receiver on the first sweep, and the first good two-way doppler data were taken on schedule at L + 1 h and 7 min. First good ranging acquisition occurred at L + 2 h and 46 min.

b. NAV/TRAG interface. Providing tracking data to the Project Navigation Team (NAV/TRAG) had been a major problem during most of the prelaunch testing because of software problems and systems reliability. However, Project data tape production went very well for the first several days of the mission. Almost every tape was provided on time, and only a few minor frequency errors occurred, which were quickly corrected. Tape handling provided another source of minor problems, which continued, but improved.

In summary, the NAV area was satisfied with NAV/TRAG interface performance with the DSN and the production of Project data tapes.

c. Trajectory correction maneuver. Motor vent and unlatch were uneventful and could be observed in the pseudoresidual listings (a comparison of actual incoming data with tracking predictions). Since the new software did not provide a plotting capability, an effort was made by TRAG to hand plot pseudoresidual output under a hard copy camera. The pitch and roll turns were plotted but were not visible in the noise of the data. It was discovered after the fact that the turns were visible in the pseudoresidual mean. The midcourse plot showed the successful execution of the burn just a few seconds behind real time. The plot is shown in Fig. 77.

d. Data quality. Tracking data were the highest quality seen in any mission to date. The only significant problems were a pass of bad DSS 12 ranging data and several early DSS 51 passes that had excessively high ranging noise. Both problems were isolated to equipment.

Extensive quantity and high quality of doppler and ranging data, coupled with new orbit software that can consistently handle both data types, led to a far more rapid stabilization of NAV orbit determination solutions than on any previous Mariner mission.

e. Real-time operations. Many procedures had to be revised with actual mission experience. Software, until the Model 2 cruise, was extremely unreliable and troublesome, yet operations did smooth out much more rapidly than expected. Necessary extensive ranging data analysis was successfully accomplished.

A major readjustment had to be made when the 360/75 was no longer available 10 hours a day because of development requirements. The necessary revision of procedures and adjustment to new shift schedules were accomplished in just 2 days.

Two minor problems were continuing: Frequencies errors in manual inputs to tracking software, and errors associated with extensive volume of tape handling.

3. Command System support. The present DSN Command System in support of the MM '71 proved reliable and efficient. No significant problem occurred to inhibit spacecraft command. In addition to the routine use of the Command System, major events occurred during the first week of flight in which the DSN Command System played a significant role. Shortly after launch, a command was transmitted to the spacecraft to acquire Canopus. During the first week of flight, commands were transmitted to the spacecraft to perform Trajectory Correction No. 1.

The command activity during a given station track ranged from one to 41 commands. In all cases, the DSN Command System performed exceptionally well. No anomalies were noted. During station track, where 41 commands were transmitted, 34 were transmitted in a 30-min period. The automatic validity checking, verification, and confirmation capabilities allowed heavy command activity during a brief time. This success attests to the efficiency of the new capabilities. From launch to the conclusion of the first trajectory correction maneuver, the following summary of command activity occurred:

Commands transmitted:	90
Commands aborted:	0
Commands delayed:	0

4. Operations Control System. Performance of the DSN Operations Control System during prelaunch through the first trajectory correction maneuver was considered satisfactory. Overall control and direction of DSN operations was executed efficiently through the mission-independent DSN OCT. This efficient performance demonstrated proper design of the operational interfaces between the DSN and Project and, within the DSN, between the OCT, the supporting NAT, and the advisors from the DSN Project Engineering Team and DSN Facility Systems. The coordination of launch-phase activities with the Near-Earth TDS

Coordinator at Cape Kennedy also demonstrated a high level of operational proficiency.

The newly developed output router (in the Monitor and Operations Control System software) was successfully used in support of flight operations. This provided the DSN with the capability for transmitting predicts and sequences of events via HSDL to the DSS and other remote sites, replacing the slower and more cumbersome method of TTY transmission.

5. Monitor System. The DSN Monitor System performance during the prelaunch phase through the first trajectory correction maneuver was excellent, with the exception of DSS 14. The DIS at Station 14 was declared red and was not available to support the Project or the DSN. The DIS at Station 14 was not declared operational until after this report period, on Oct. 15, 1971.

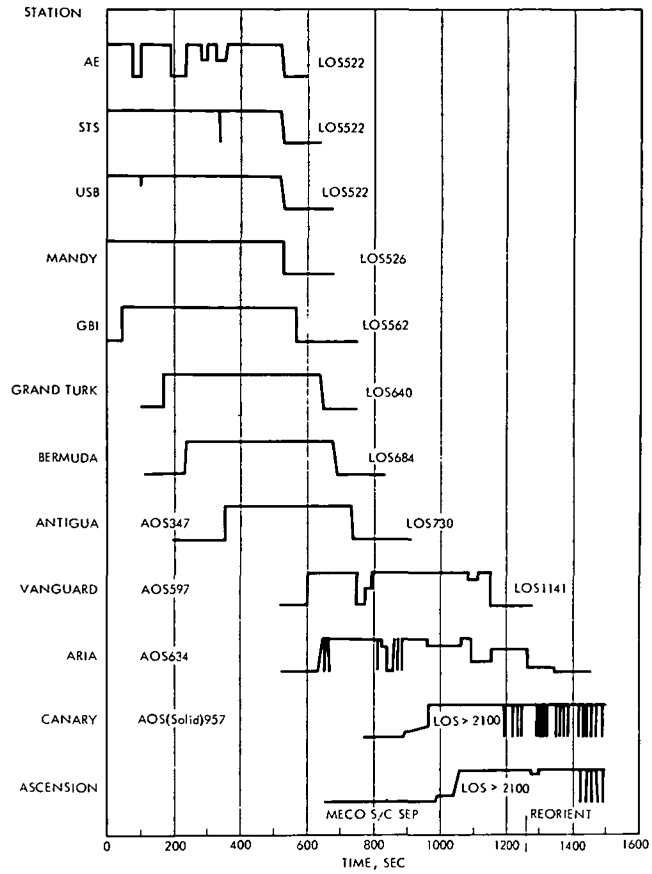


Fig. 71. Centaur telemetry data, percent usability

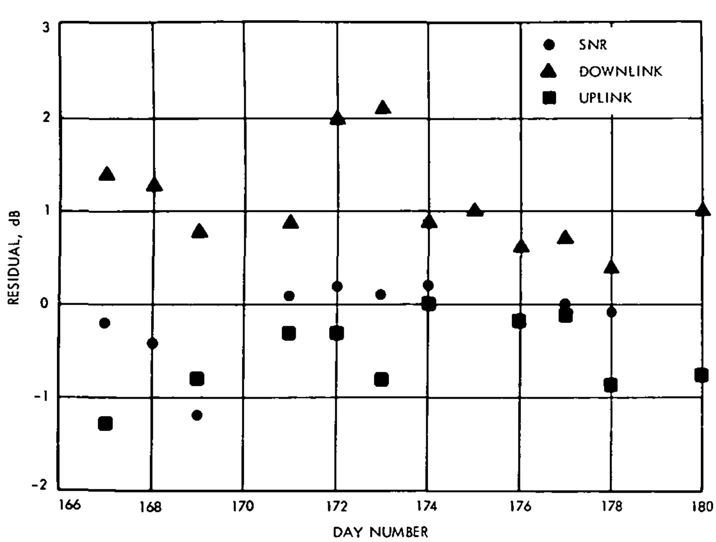


Fig. 72. Residual data plot for DSS 12

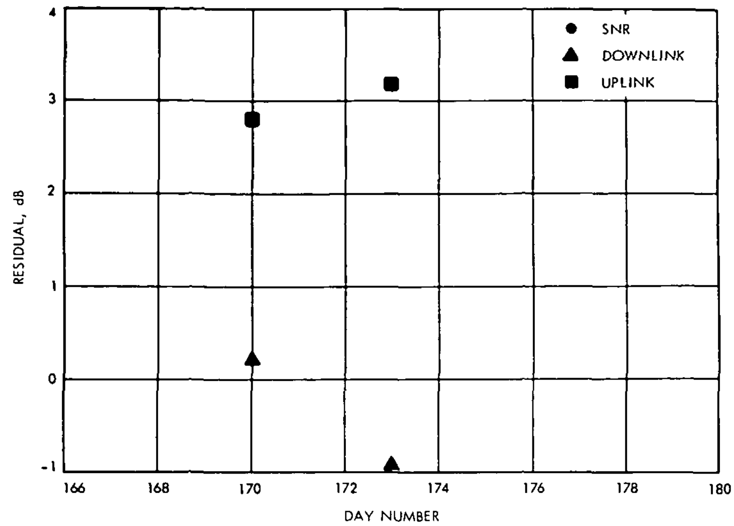


Fig. 73. Residual data plot for DSS 14

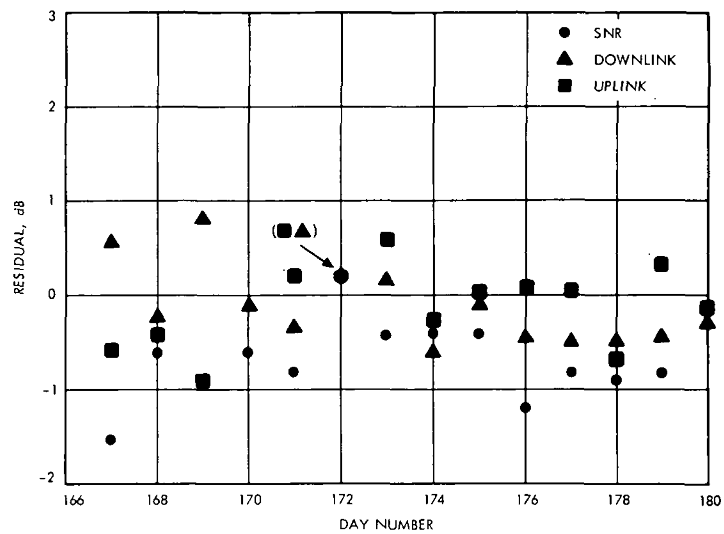


Fig. 74. Residual data plot for DSS 41

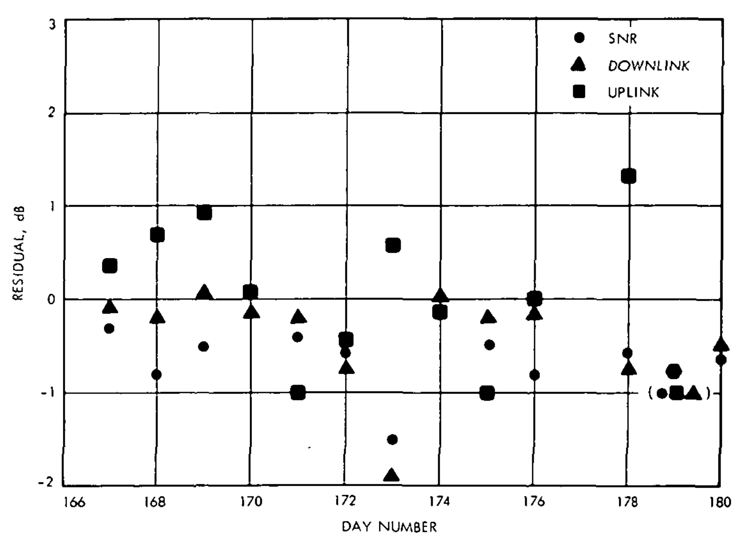


Fig. 75. Residual data plot for DSS 51

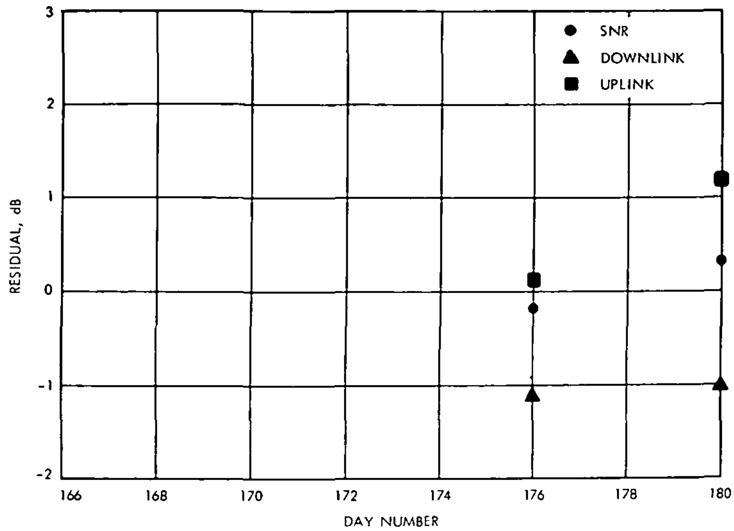


Fig. 76. Residual data plot for DSS 62

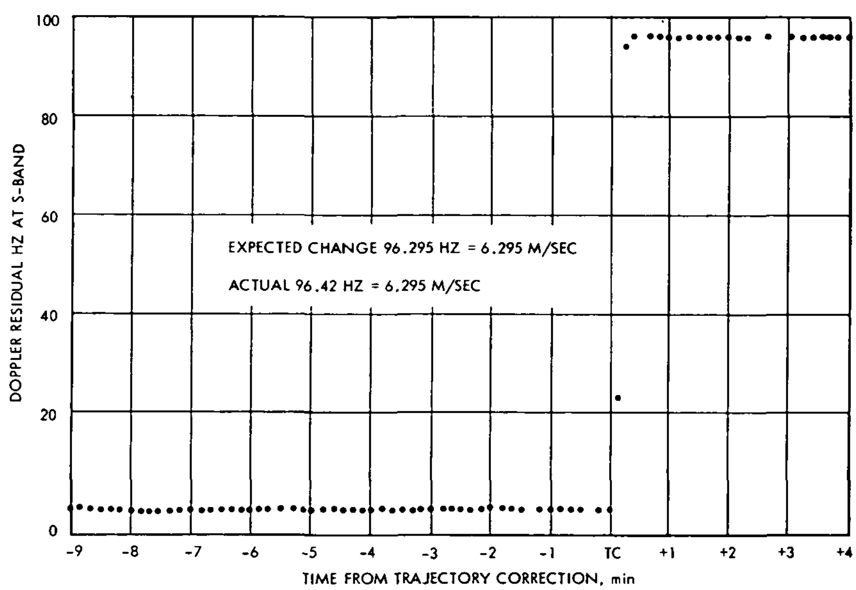


Fig. 77. Pseudoresidual plot for trajectory correction maneuver

GLOSSARY

A/C	attitude control
ACMO	Assistant Chief of Mission Operations
ACN	Ascension Island, GSFN Station
AD	arrival date
ADSS	Automatic Data Switching System
AFETR	Air Force Eastern Test Range
AGC	automatic gain control
AIS	Apollo Instrumentation Ship
AMPS	Adaptive Mode Planning System
ANT	Antigua Island, AFETR Station 91
AOS	acquisition of signal
APS	Antenna Pointing Subsystem
ARIA	Apollo Range Instrumentation Aircraft
ASC	Ascension Island, AFETR Station 12
ASU	automatic selector unit
AZ	azimuth
BCD	binary-coded decimal (information code)
BDA	Bermuda, GSFN station; Block Decoder Assembly
BDXR	block demultiplexer
BECO	booster engine cutoff
BER	bit error rate
BIH	built-in hold
bit	binary digit
BMXR	block multiplexer
BOD	beneficial occupancy date
BSN	block serial number
CAG	Command Analysis Group; Canopus acquisition gate
CAT	Complementary Analysis Team
CC	coded commands
CCF	Central Computing Facility
CC&S	central computer and sequencer
CCTV	closed-circuit television
CIF	Central Instrumentation Facility
CLT	Communications Line Terminal
CMA	Command Modulator Assembly
CMD	command
CMO	Chief of Mission Operations
COMGEN	Command Generation Program
CONF	conference
CONT	control
CP	Communications Processor
CPS	Central Processing System
CPT	Capabilities Planning Team
CPU	Central Processing Unit
CRT	cathode ray tube
CTA 21	Compatibility Test Area, JPL, Pasadena, Calif.
CVT	configuration verification test
CYI	Grand Canary Island, Spain, GSFN Station
DAS	Data Automation Subsystem
DC	direct command
DDT	data dependent type
DIS	Digital Instrumentation Subsystem
DoD	Department of Defense
DPT	Data Processing Team
DPCC	Data Processing Control Center
DR	discrepancy report
DRS	Discrepancy Reporting System
DRVID	Differenced Range vs Integrated Doppler (charged particle measurement)
DSIF	Deep Space Instrumentation Facility
DSN	Deep Space Network
DSCC	Deep Space Communications Complex
DSS	Deep Space Station
DSS 11	Pioneer Deep Space Station, Goldstone, California
DSS 12	Echo Deep Space Station, Goldstone, California
DSS 13	Venus Deep Space Station, Goldstone, California
DSS 14	Mars Deep Space Station, Goldstone, California
DSS 41	Woomera Deep Space Station, Island Lagoon, Australia

DSS 42	Tidbinbilla Deep Space Station, Canberra, Australia
DSS 51	Johannesburg Deep Space Station, Johannesburg, South Africa
DSS 61	Robledo Deep Space Station, Madrid, Spain
DSS 62	Cebreros Deep Space Station, Madrid, Spain
DTS	Digital Tracking Subsystem
DTSS	DSIF Tracking Subsystem
DTV	digital television
DUT	constant relating Ephemeris Time to Universal Time
EDED	error detection encoder-decoder
EDR	experiment data record
EOM	end of mission
ET	Ephemeris Time
ETL	Environmental Test Laboratory, JPL
FAX	facility
FCS	Frequency Control System; Flight Command Subsystem
FDX	full duplex
FSK	frequency shift keying
FTS	Flight Telemetry Subsystem
GCF	Ground Communications Facility
GD/C	General Dynamics/Convair
GEN	generator
GMT	Greenwich Mean Time (Zulu time)
GRTS	Goddard Real-Time System
GSFC	Goddard Space Flight Center, Greenbelt, Maryland
GSFN	Goddard Space Flight Network of Near-Earth Phase Stations
HSD	high-speed data
HSDL	high-speed data line
HSS	High-Speed System
I	insertion
ID	identification
ILT	idle line termination
I/O	input/output
IRIG	Inter-Range Instrumentation Group
IRIS	infrared interferometer spectrometer
IRR	infrared radiometer
IRV	inter-range vector
JPL	Jet Propulsion Laboratory
KSC	Kennedy Space Center
L	launch time; T = 0
LAD	latest available date
LERC	Lewis Research Center
LOX	liquid oxygen
LTDS	Launch Trajectory Data System
MCD	monitor criteria data
MCDX	Monitor Criteria Data Program
MCUI	Master Control and User Interface
DC	Mission Decision Center
MDR	Master Data Record
MECO	main engine cutoff
MED	manual entry device
MEDIA	transmission media subassembly
MES	main engine start
MIL	Merritt Island, AFETR Station
MM '71	Mariner Mars 1971 Project
MMCD	Master Monitor Criteria Data File
MMCS	Multi-Mission Command System
MMT	multi-mission telemetry
MOD	modulator
modem	modulator/demodulator
MOPS	Maneuver Operations Programming System
MOS	Mission Operations System
MSA	Mission Support Area
MSFN	Manned Space Flight Network
MTC	Mission Test Computer
MTG	meeting

MTVS	Mission Test and Video System
MUX	multiplexer
NA	not applicable
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications Network
NAT	Network Analysis Team
NAV	navigation, Navigation Team
NEP	near-Earth phase
NETDS	Near-Earth Tracking and Data System
NRZ	non-return-to-zero
NSP	NASA Support Plan
NTTF	Network Training Test Facility
OC	Operations Control or Operations Chief
OCT	Operations Control Team
ODC	operation data control
ODE	orbital data editor
ODR	Original Data Record
ODT	operational demonstration test
OPS	operations
ORT	operational readiness test
OSE	operational support equipment
OVT	operational verification test
PAFB	Patrick Air Force Base
PAM	phase amplitude modulation
PAS	pyrotechnic arming switch
PCM	pulse code modulation
PE	Project Engineer
PET	probe ephemeris tape
PFR	problem/failure report
PLATO	Platform Observables Subassembly
PN	pseudonoise
PRD	Program Requirements Document
PRDX	Prediction Program
PSK	phase shift keying
PTT	project tracking tape
QC	quantitative command
RADDAC	Radar Data Acquisition Center
RCP	right circular polarization
RCVR	receiver
R&D	research and development
REC	recording
RF	radio frequency
RFS	Radio Frequency Subsystem
RSC	Range Safety Command
RTCF	Real-Time Computer Facility
RTCS	Real-Time Computer System
RTLT	round trip light time
RTTDS	Real-Time Telemetry Data System
RWV	read-write-verify
SAA	S-band acquisition antenna
SAF	Spacecraft Assembly Facility (Building 179, JPL)
S/C	spacecraft
SCA	Simulation Conversion Assembly
SCF	Scientific Computer Facility
SCI	science
SCO	subcarrier oscillator
SCT	SFOF Communications Terminal
SDA	Subcarrier Demodulator Assembly
SDR	System Data Record
SDT	Science Data Team
SECO	sustainer or second engine cutoff
SEG	Sequence of Events Generator Program
SFOF	Space Flight Operations Facility
SFOP	Space Flight Operations Plan
SIG	signal
SIMCEN	Simulation Center
SIRD	Support Instrumentation Requirements Document
SIT	spacecraft-initiated timer

SMC	Station Monitor and Control Subsystem
S/N	serial number
SNR	*signal-to-noise ratio*
SNT	system noise temperature
SOE	Sequence of Events
SOPM	standard orbital parameter message
SPE	static phase error
SPX	simplex
SRO	Superintendent of Range Operations
SRT	Science Recommendation Team.
SS	subsystem
SSA	Symbol Synchronization Assembly
ST/N_0	ratio, signal energy per bit/noise spectral density
STS	Satellite Tracking Station
T	elapsed time from launch; T = 0 at launch L
TAER	time, azimuth, elevation, and range
TCD	Telemetry and Command Data Handling Subsystem
TCF	Test Computer Facility
TCP	Telemetry and Command Processor
TDA	tracking and data acquisition
TDH	Tracking Data Handling Subsystem
TDM	time division multiplex
TDP	Tracking Data Processor
TDS	Tracking and Data System
Telcomm	*telecommunications*
TLM, T/M	telemetry
TRAG	Tracking Analysis Group
TSAC	Tracking System Analytical Calibration Program
TTY	teletype
TV	television
TVSA	television assembly
TWTA	traveling wave tube amplifier
ULO	unmanned launch operations
USB	unified S-band, upper sideband
UT	Universal Time
UT&D SS	User Terminal and Display (UTD) Subsystem
UVS	ultraviolet spectrometer
VCO	voltage-controlled oscillator
VECO	vernier engine cutoff
VID	Video Image Display Assembly
VHF	very high frequency
WB	wideband
WBDL	wideband data line
WBDS	wideband data system
WCSC	West Coast Switching Center
XMTR	transmitter

APPENDIX A

GSFC NETWORK POST-TEST (TTY) REPORT FOR MM '71

MIL AOS

	GMT / HHMMSS/	GET / HHMMSS/	GET/ SEC/	SIGNAL LEVEL DBM
ATLAS RF	231725	-015337	-6317	-63
ATLAS TLM	010900	-000202	-122	NA
CENTAUR RF	231725	-015337	-6817	-65
CENTAUR TLM	010900	-000202	-122	NA
S/C RF	224225	-022337	-13,232	-75
S/C TLM	010900	-000202	-122	NA

MIL LOS

ATLAS RF	011922	000820	500	-110
ATLAS TLM	011348	000746	466	NA
CENTAUR RF	011933	000831	511	-110
CENTAUR TLM	011348	000746	466	NA
CENTAUR IRIG	13			
S/C 33.3 BPS	011655	000553	353	NA
S/C RF	011936	000834	514	-140
S/C TLM	011936	000834	514	NA

MIL VERBALLY REPORTED THE UNIFIED S-BAND 30-FOOT X-Y ANTENNA SYSTEM UTILIZED FM AUTOTRACK ON THE CENTAUR TLM DOWNLINK DURING ITS DATA INTERVAL EXCEPT FOR A VERY BRIEF PERIOD WHERE PROGRAM TRACK FROM PREFLIGHT NOMINALS WAS UTILIZED DURING A SHORT PERIOD OF CENTAUR DOWNLINK SIGNAL FADE.

S/C: "RF SIGNAL STRENGTH FLUCTUATED BADLY"
CENTAUR: "SIG. STRENGTH FLUCTUATED BADLY"
ATLAS: "RF SIGNAL STRENGTH FLUCTUATED BADLY"
"NA" IS NOT AVAILABLE

BDA AOS

	GMT / HHMMSS/	GET / HHMMSS/	GET/ SEC	SIGNAL LEVEL DBM
ATLAS RF	011502	000400	240	NA
ATLAS TLM	011510	000403	243	NA
CENTAUR RF	011501	000359	239	-90
CENTAUR TLM	011506	000404	244	NA
S/C RF	011455	000353	233	-100
S/C TLM	011530	000423	263	NA
Q-6 RDR RF	011536	000434	274	NA
Q-6 RDR TRK	011554	000452	292	33$
16 RDR RF	011510	000403	243	NA
16 RDR TRK	011518	000416	256	15$

2. BDA LOS

ATLAS RF	012000	000358	533	NA
ATLAS TLM	012000	000353	533	NA
CENTAUR RF	012015	000913	553	-95
CENTAUR TLM	012014	000912	552	NA
CENTAUR IRIG	13			
33.3 BPS	011654	000552	352	NA
S/C RF	012015	000913	553	-105
S/C TLM	012014	000912	552	NA
C-6 RDR RF	012018	000916	556	NA
C-6 RDR TRK	012018	000916	556	20$
16 RDR RF	012020	000913	558	NA
16 RDR TRK	012018	000916	556	10$

$: THIS IS SNR IN DB REFERENCED TO 0 DBM.
BDA VERBALLY REPORTED THE UNIFIED S-BAND 30-FOOT X-Y ANTENNA SYSTEM UTILIZED PREFLIGHT NOMINAL ACQUISITION DATA WHICH PLACED THE ANTENNA ON A VALID INTERCEPT LOOK ANGLE FOR HORIZON AOS. FM AUTOTRACK WAS UTILIZED FOR ANTENNA POINTING FROM AOS TO LOS.
S/C: "SIGNAL LOBING THROUGHOUT PASS"
CENTAUR: "SIGNAL LOBING THROUGHOUT PASS"
ATLAS: NO COMMENT AVAILABLE
THE BDA ON-SITE COMPUTER PROBLEM (MINUS TIME) IS STILL UNDER INVESTIGATION. MSFNOC CARRIED ONE RED, ONE GREEN INTO PLUS TIME. BOTH WERE PROBABLY GREEN IN PLUS TIME. NO IMPACT TO MISSION SUPPORT

MARK EVENT SUMMARY

MIL		BDA			
REPORTED TIMES		REPORTED TIMES		NOMINAL TIMES	
TLM 01:11:02.3Z		TLM 01:11:02.3Z		TLM 01:07:00Z	
MARK EVENT GMT	/ GET	GMT	/ GET	GMT	/ GET
HH MM:SS.S	/HH MM:SS.S	HH MM:SS.S	/HH MM:SS.S	HH MM:SS.S	/HH MM:SS.S
1 0113:31.3	0002:29.9			0109:27.9	0002:27.9
2 0113:34.2	0002:31.9			0109:31.0	0002:31.0
3 0114:16.2	0003:13.9			0110:12.9	0003:12.9
4 0114:58.1	0003:55.3			0110:54.9	0003:54.9
5 0115:14.9	0004:12.3			0111:10.9	0004:10.9

6	0115:17.6	0004:15.3			0111:12.9	0004:12.9
7	0115:23.1	0004:25.8	0115:23.2	0004:25.9	0111:22.4	0004:22.4
8	0116:56.1	0005:53.8	0116:56.0	0005:53.7	0118:56.5	0011:56.5
	0117:05.4	0006:03.1	0117:05.5	0006:03.2		
	0117:41.4	0006:39.1				
9			$$		0120:31.5	0013:31.5

(GDC CHECK LISTING TRAJ)
(APPENDIX A TO FIRING TABLES)

$$: BDA MONITORED (PER MSFN DOCUMENTATION) CD 7V RSC NO.
2 RCVR AGC:
CHANNEL 9 DATA SEGMENT 5 (COMMUTATION SEGMENT 9) INSTEAD OF CM 125X MM-71 S/C SEP RELAY 1, CM 126X MM-71 S/C SEP RELAY 2:
CHANNEL 8 DATA SEGMENT 5 (COMMUTATION SEGMENT 9) FOR REPORTING MARK EVENT 9, S/C SEPARATION. BDA REPORTED "100 PERCENT (OF FULL SCALF) THROUGHOUT PASS." THE ERROR IN DOCUMENTATION WILL BE CORRECTED FOR MM-71 I LAUNCH.

4. VAN - NO VIEW
5. CYI - NO VIEW
6. ACN - NO VIEW

7. TAN - NO VIEW
8. MSFN/NASCOM - NO PROBLEMS
9. IMPACT PREDICTION

STATION	LAT (NORTH)	LONG (WEST)	TIME	TIME REPORT
GSFC	24 DEG	64 DEG		0123Z
COMPUTERS	24.035 DEG	65.47 DEG		0207Z
BDA	23 DEG 30 MIN	64 DEG 25 MIN	0121Z	0127Z
ETR			0121Z	
JPL	23.7 DEG	64.5 DEG	0121Z	09/0220Z
MOS				JJPL

NASA — JPL — Coml., L.A., Calif.